THE TRACKMAN'S HELPER

REVISED

TWENTIETH CENTURY EDITION.

THE

TRACKMAN'S HELPER

REVISED TWENTIETH CENTURY EDITION

A BOOK OF INSTRUCTION

FOR

TRACK FOREMEN

BY

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CHICAGO
ROADMASTER AND FOREMAN, PUBLISHERS
91-93 South Jefferson St.
1900

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PREFACE.

THE TRACKMAN'S HELPER is one of the Pioneer Track Books of America and of the world, because in other countries no books of the kind were published when the work was first issued. Mr. Kindelan, the veteran trackman, and author of the original work, made the following statement in his preface:

"That there is a necessity existing for such a book is admitted by every good trackman, and I have received many letters from prominent trackmen, and other railroad officers throughout the United States, who all agree in the opinion expressed, that all trackmen should be supplied with a book of instructions, which would advance their knowledge of theoretical and practical details of Construction and Track Maintenance quicker than such knowledge can be gained by actual experience, this would fit them for doing all work in a practical manner, with less inconvenience to themselves and in a way that would be more satisfactory to the company. * * * * * * * * *

"After a certain amount of time has elapsed since a man has entered the service, his natural aptitude for gathering knowledge along with what instructions he receives, will make him a good average trackman, and familiarize him with the rules of the road and his other duties, but unless he has had the benefit of a wide field of experience and a very thorough training, he seldom becomes so expert as to be able to do in a

proper manner many kinds of work with which he is unacquainted, but which he may be called upon to do at any time.

"To help fill this want of the Trackman, the writer published the first edition of this book, which I hope has proved to be what its name indicates, a Helper for Trackmen.

"I fully realized how difficult a task it would be to write a book which would be accepted by even a majority of the Trackmen of the country, but as I have had a practical education, from the shovel up, I thought I could offer something that would at least assist the ambitious young trackman seeking knowledge of his profession. I deemed it my duty, also, to put into book form the practical knowledge I possessed, if for no other reason than to show the importance of the Track, in relation to the other Railroad Departments, and assist in bringing more uniformity into the methods of doing track work on the different railroads."

These words were written a number of years ago, before Trackmen were accustomed to anything at all in the way of reading matter relating to their calling, but the expressions of the practical and veteran Trackman have proven true in every instance. The "necessity existing" soon secured a standing for the work in sales amountig to 20,000 copies, and this army of readers have all added their testimony to the fact that the book is, in truth, a "Helper for Trackmen."

Since the original work was prepared, many improvements and changes have been made in the Maintenance of Way Department, and a revision of the work was necessary in order to eliminate many matters now obsolete and to bring the work thoroughly up to

date. The new Twentieth Century Edition of the Trackman's Helper, revised and improved in every way, making it a book for North, South, East and West, is herewith presented. The subject is so extensive that a work of this kind might be easily enlarged to 1,000 pages, but it was necessary to confine the work to something near its original scope, which required a careful selection of the most practical topics of interest to Trackmen, and their condensation in plain language and in convenient form, with a handy index and paragraph number.

The revision has been under the supervision of F. A. Smith, C. E. M. E. Editor, Roadmaster and Foreman; F. R. Coates, late Roadmaster, New York, New Haven and Hartford Ry., and Jerry Sullivan, Division Roadmaster, Choctaw, Oklahoma and Gulf Ry.

The publishers, in presenting the new work, can offer no better sentiment than that expressed by Mr. Kindelan, in his preface to the Third Edition:

"If by the publication of this book I have laid one more stone in the arch which would span the gulf of prejudice and support all good Trackmen in a common effort for the welfare of each other, and the upbuilding of their profession, I have accomplished enough, and I sincerely hope that what little I have added to the track literature now in existence may only be the beginning of something better and more worthy."

THE PUBLISHERS.

CHAPTER I.—CONSTRUCTION.

REQUIREMENT OF NEW TRACK.

1. A Good railroad should be complete in all respects; track should be full bolted, full spiked, well ballasted, surfaced, lined, and gaged, and nothing omitted in its construction which would contribute toward making it a perfect and safe track. A poor track no more deserves to be called a railroad than a shanty does to be called a house, and trackmen who are in the habit of doing poor work with the means at hand to do better, never learn how to do good work.

TRACK LAYING.

2. The best dirt ballasted track can be made when laying it, by bedding the ties to a level surface on top before putting on the rails. To lay track this way, the company's engineers must first set level stakes by which to bed the ties, and these stakes should be close enough together for a sixteen-foot straight edge to reach from one stake to the next. To have the engineer set level stakes so close together that a straight edge will reach from one stake to the other is contrary to the common practice, but it is a much better way in so much that the increased labor of the engineer is fully compensated for in having the whole tie bedding gang under the control of one foreman. This method also does away with the necessity of using sight boards and dividing up the men to sight in the

lead ties between level stakes fifty or one hundred feet apart. The work is also more accurate when finished, if the straight edge can reach a level given with the engineer's instrument, than it would be, if the levels were sighted in by the average track laborer.

TRACK-LAYING MACHINES.

3. Track-laying machines have been used to a considerable extent when building new roads during recent years. When track is laid with them the ties and rails are run out along the material cars to the front, on rollers in some cases, and in others an endless belt carries out the material along the sides of the cars. Only one or two rails of track are laid at a time, and partly spiked, then the train moves up and the same operation is performed again. Economy in the force of men necessary to lay track with these machines, together with the saving effected by not having to haul the ties by team to the front, are the chief claims put forward in their favor. But the amount of track laid each day must always be limited to what can be bolted and spiked safe for trains, between the forward moves of the machine, seldom exceeding a mile and a half in a day, and oftener one-third less. In a good country to lay track where ties can be hauled ahead by team, and men are plenty, much better results can be obtained without track-laying machines, if it is desired to rush the track laying.

HAVE TOOLS READY.

4. Every good trackman knows the tools which his men should use, and before starting out to lay track on a new road the foreman should make requisition for all the necessary tools. These tools should all be loaded into a car and shipped direct to the point where work is to be commenced. Everything should

be in readiness to make a good beginning, before the men are brought upon the ground. Many awkward and serious delays have been caused by the foreman in charge neglecting to see to the arrangements in time for working his men properly.

5. TRACK-LAYING TOOLS AND MATERIAL.

Hand Cars	1	Nail Hammers	3
Steel Cars	3	Monkey Wrenches	3
Push Cars	2	Lanterns, Red	3
Shovels, R. R.	150	Lanterns, White	3
Picks	50	Water Pails	6
Lining Bars	12	Tin Dippers	6
Claw Bars	12	Oil Cans	2
Tamping Bars	12	Oilers	3
Nipping Bars	24	Gallons of Oil	2
Cold Chisels	24	Nails	1 keg 10 penny
Rail Punches	6	Nails	1 keg, 20, 40, 60
Chopping Axes	6	Pick Handles	24
Hand Axes	6	Track Jacks	4
Adze Handles	6	Rail Benders	2
Axe Handles	6	Covered Water Barrels	2
Maul Handles	36	Track Levers	2
Red Flags	12	Chalk Lines	2
Sledges, 16 pounds each	3	Files	6
Grind Stones	1	Crosscut Saws	2
Track Wrenches	24	Curving Hooks	2
Iron Tongs, pairs	3	Post-hole Diggers	2
Rail Forks	6	1¼-inch rope	300 feet
Expansion Shims	200	Tie Poles, 30 feet long	2
Switch Locks	6	Tie Line, 1,000 feet long	1
Rail Drills	2	Tie Square	6
Torpedoes, dozens	4	Set Double Harness	1
Spiking Hammers	42	Set Single Harness	1
Bush Scythes and Snaths, each	3	Set Double and Single Trees	1
Hand Saws	6	Wagons	1
Adzes	6	Scrapers	1
Track Gages	12	Horses or Mules	2
Spirit Levels	6	Tool Boxes	2
Tape Lines	6		

The above list of tools will do to supply an average gang of 100 tracklayers with a surplus to equip extra

men if required, or replace tools out of repair or broken, until supplies ordered can be gotten to the front. The accommodations for tracklaying should be about as follows:

One supply and office car.
One kitchen car.
Two dining cars.
Four sleeping cars.

Where track laying is done at a long distance from the base of supplies a blacksmith with forge and tools should accompany the outfit.

TIE BEDDING.

6. The work of tie bedding consists in placing a straight edge in a level position over the top of loose ties lying on the grade, and bringing up each tie to a uniform surface under the straight edge, just as it should lie in track under the rails. Thin ties should have dirt or ballast thrown under them and be settled to the correct level. The bed under thick ties should be dug out and the dirt removed sufficiently to bring the tie down to the level of the other ties. One straight edge should be provided for every two men of the tie bedding gang. When it is intended to ballast the track with dirt from the embankment, the thick ties should always be bedded before laying the rails, for the reason that the grade is seldom or never a smooth surface to receive the ties; moreover, the ties, no matter how well selected, are of different thickness, and it is well known that light rails, laid on loose ties on a poor grade, will be kinked and damaged considerably by trains running over the track before it is surfaced up smooth and level. Another good point in favor of tie bedding is that the rails can be laid much faster than over loose ties and the spiking can be done better and with less labor.

Engineers should call the attention of the contractor to inequalities or poor surface of grade. It is much easier and cheaper to make a good grade with teams and scrapers than with shovels. In fact, the boss tracklayer cannot spare the men necessary to do this fast enough to keep ahead of the rails. An engineer who would accept a poor grade from a contractor—well, he might not be a thief, but that is the way to enrich a contractor and impoverish a railroad company. The grade through cuts should be closely watched to see that the earth is removed down to grade. If this is done there will be no hump in the track and the cost and delay incidental to bedding should be done very sparingly, because the grade will settle in a short time so that the track will have to be raised.

OMIT THE TIE BEDDING.

7. If it is intended to ballast track with cinders, gravel or stone, as fast as it is laid, the tie bedding should be omitted in order to have the full width of the grade to deposit the ballast upon, but at the same time the ballasting should be kept finished up close behind the tracklayers to obviate the danger of spoiling rails.

Very few trackmen realize the necessity or make much effort to protect the rails from being kinked or surface bent, when laying track, and a large part of new track throughout the United States bears evidence of their carelessness.

All railroad companies are more liberal when constructing than they are when the road is in operation, and if a company lay their own track the man in charge of the work should see that it is done well, even if the cost is greater. It pays in the end. When the

work of constructing a railroad is poorly done it is never finished afterwards.

GOOD MEN AT THE FRONT.

8. When building new road the man in charge of the track laying should endeavor to secure good, sober men to work at spiking and laying the rails, because on the front men, in a great measure, depends the amount of track laid every day. The spikers and ironmen should be paid better wages than the other men, not alone on account of the work, but to encourage them to do their best, and also, that you may secure picked men to fill their places whenever needed. All the men at tracklaying should be well organized; each man should have his particular work to perform. The men should not be allowed to work promiscously, changing from one place to another. One foreman should have charge of the ironmen, another of the spikers, and a third of the surfacing crew, all subject to the foreman tracklayer. It is poor economy to try to lay track without any of the three foremen mentioned, as is sometimes done, because, although a good tracklayer may be able to oversee a considerable number of men, he cannot look after the details of the work in its different branches, and give it the required attention, without the assistance of these foremen except where the work is done with a small gang of men.

A SURFACING GANG.

9. When laying track it is always best to keep at least a small surfacing crew behind to recruit from, if you are short of men at the front, and any extra men at the front should be put to surfacing.

The amount of supplies taken out each day should be in proportion to the number of men you are working, and only enough should be taken out at one time

for a good half day's work, because much more than that amount would only be in the way and delay the work. Where the ties for a new track are hauled out along the grade by teams it is always best to let the work out by contract. This will save the neccssity of hiring and watching the teamsters and insure the work being done without delay.

LOCATING JOINT TIES.

10. Every tracklayer should have two men to carry a measuring pole the correct length of a rail for locating the joint ties, ahead of the rails. These men should also space the ties on each side of the joint wherever necessary. They could also adze twisted ties and bed down ties which were too high. The joint ties should not be located very far ahead of the rails, because there is liable to be variation in the distances, and the measurements taken with the pole should be corrected from the end of the rails occasionally. The track laying is delayed and the ties are seldom as well spaced when this work is left to the spikers.

LAYING THE RAILS.

11. A construction foreman should see that no new rails be laid in a new track before all kinks and crooked places in the rails are straightened. It is a common fault of track foremen when in a hurry to throw down all rails just as it comes to the front, regardless of any kinks that may have been put in the rails while in transit, or in dumping them off cars. Many lightweight rails are irreparably damaged in this way, and after such rails are put in a track they are seldom, if ever, made perfect again, as hardly ever section foremen have the necessary amount of help, or spare time to do what could have been done in a very short time before the rails were laid. The foreman tracklayer

should see that the rails are laid so that no joint will come within ten feet of the end of any bridge or cattle guard, where it is possible to avoid doing so. This can be done easily if the track is laid with even joints, but not so well with broken joints.

EXPANSION AND CONTRACTION.

12. Track foremen, when laying rails, should be very particular to give the proper space at the joints for expansion. Avoid leaving the joints too close in cold weather, or too much open in warm weather, either of which causes much trouble afterwards.

As soon as the weather becomes warm, rails which were laid in the track with very close joints, during colder weather, begin to expand and increase in length, as the heat increases, until the opening between the ends of the rails is entirely closed. After this, as there is no further room for expansion, the track is forced out of line, and kinks are put in the shoulder of light-weight rails. This extreme expansion is very dangerous for fast trains, and in many cases has been the cause of wrecks. The effect of expansion of the rails is most noticeable on the line of track which is only partially ballasted and filled between the ties, or where track has been laid down without any particular ballast.

HEAT AND COLD.

13. Contraction is a shrinking or shortening up of the rails, and is caused by cold weather. The contraction of the rails increases with the severity of the cold, and by this process, the opening in the joint between the rails is enlarged.

Sometimes in the winter the contraction is so great that where the rails were not properly laid, the track is torn apart, joint splices are broken, and openings

between the rails are increased from three inches to a foot, rendering the track extremely dangerous for trains, unless discovered in time by the trackmen and repaired.

Too much space at the joints also affects the wearing qualities of the rails, the opening at the joint being so large that the car wheels batter their ends, and they wear out and have to be taken out of service much sooner than rails of the same quality if laid with the proper spacing on another part of the road.

About the first of June and December of each year the bolts should be loosened and the rails allowed to adjust themselves to the change in temperature. In summer only the bolts on open joints and in winter those on closed joints need be loosened. After loosening the bolts the angle bars should be tapped with a hammer to loosen the rust between angle bar and rail, and after the rails have moved to their proper place the bolts should be retightened.

EXPANSION TABLE.

14. The coefficient of expansion for steel is .0000065 of its length for each degree. For a rail 30 feet long and a difference of 100 degrees, or from 10 degrees below zero to 90 degrees, the amount to allow would be one-quarter inch. To take up the flow of the rail, add one-eighth to this, and the total amount to allow is three-eighths. Leave the following expansion when laying track between the ends of the rails at any temperature:

Temperature.	Amount of Expansion.
At 90 degrees above zero	1-16 of an inch
At 70 degrees above zero	1-8 of an inch
At 50 degrees above zero	3-16 of an inch
At 30 degrees above zero	1-4 of an inch
At 10 degrees above zero	5-16 of an inch
At 10 degrees below zero	3-8 of an inch

A steel rail expands or contracts 1-100000 of a length under a load of one ton (2,240 pounds) per square inch. This is also its expansion under a rise of 15 degrees of temperature; consequently, if a 30-foot rail is subjected to a rise or fall of 15 degrees, it exerts a force of one ton per square inch if resisted. With this fact in mind, is it any wonder that so many joints buckle and bolts break when the proper amount of attention has not been given the expansion?

The amount of expansion stated should not be exceeded in any case. It is not unusual to find track with many joints wide open during the hottest days in summer. When track is laid with the temperature at 90 degrees above zero, instead of using 1-16-inch expansion shims at each joint use one-eighth at every other joint, or if no one-eighth inch shims are carried, one-quarter inch shims may be used by putting them at every third or fourth joint, as the case may require, and lay the other joints tight.

Expansion shims should be made of narrow, flat iron or steel, and bent so that one end would rest on top of the rail when in place. The shim could thus be easily removed and used again, after a piece of track was laid, and all the bolts then tightened up on the joint fastenings.

A ten-penny common steel nail, if bent at right angles, makes a cheap and handy expansion shim when no others are provided. It may be used at almost any temperature above the freezing point, by reversing the end and flattening the head of the nail. Expansion shims should not be allowed to remain between the ends of the rails after a piece of track is laid and the joint fastenings have been made secure.

Care should be taken when laying old rails, to make

the same allowance for expansion as when laying new rails.

TRANSFERRING MATERIAL.

15. Owing to the scarcity of flat cars on railroads, box cars or stock cars are often used to ship rails to the front when track laying. All rails which come in this manner have to be transferred to flat cars at certain points, in order to facilitate handling them before laying at the front. The transfer of rails from box or stock cars can best be accomplished by switching empty flat cars between the loaded cars and attaching framed rollers to the end doors of the loaded cars to run the rails out upon. A hollow iron roller can also be used to place under the rail within the loaded car, and one upon the flat car where it receives the rail. If this is done a large quantity of rails can be transferred in a day with a small crew of men. The transfer foreman should keep posted as to the quantity and different kinds of material wanted at the front, and he should make every effort to forward the supplies so as not to delay the track laying. He should also keep an accurate and detailed account of all track material, or other supplies which passes through his hands.

MIXED LENGTHS OF RAILS.

16. When it is possible to avoid it mixed lengths of rails should not be used when laying track. The cost of repairing such a track is always greater than a track laid with rails of a uniform length, and when the rails begin to wear out there is a large amount of material wasted and time lost by replacing the battered rails from rails of a different length for repairing. When tracklayers find it necessary to get rid of a mixed lot of rails, the best place to lay them is in a side track, matching all rails of an equal length or height. When

there is not room for mixed rails in side tracks, lay them in the main track close to or at a station; there the track is safer, and the section man can do the necessary repairing or changing of rails at less cost, and to better advantage than out on his section; and when thus laid, keep the same lengths together.

SHORT RAILS FOR CURVES.

17. When laying track where curves are frequent, diagrams should be prepared, as shown in Fig. 1, to avoid confusion in forwarding material at the front and laying the track.

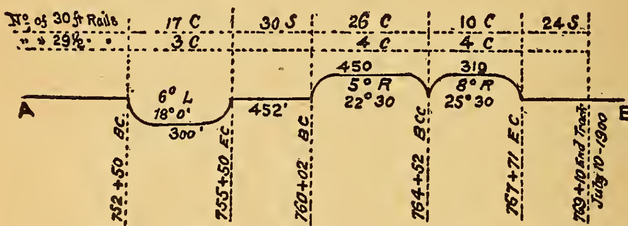


FIG. 1.

The line A B represents the center line, showing a 6-degree curve to left, followed by a tangent of 452 feet, thence a 5-degree curve to right compounding into an 8-degree curve. The line is to be laid with 30-foot rails, using 29½-foot rails on the inside of curves to square joints. Each curve is marked with the degree and the total angle. Below the line A B is given the lengths of the tangents and the curves in feet, also the station numbers of the beginning and end of curve.

Above the line A B is given the number of rails for each tangent, and the number of 30-foot and 29½-foot rails for each curve. One 29½-foot rail is laid for each 6 degrees of angle in the curve. The compound curve contains a total of 48 degrees of angle, requiring eight 29½-foot rails to square the joints. At the end of each

day's work the station of the end of track should be marked on the diagram.

In the material yard, with the aid of the diagram, the foreman will know just what kind of material to forward each day. On the side of each loaded car the foreman should nail a piece of board or shingle, upon which is plainly written the kind of material on the car, as:

40 S. Rails.
17 C Rails for 6-degree Lt. Sta., 753.
3 C Rails 29½-ft. for 6-degree Lt. Sta., 753.

The straight rails should be separated from the curved with pieces of board. When laying with a track-laying machine it is more convenient to put the 29½-foot rails on the car of trimmings.

A diagram is given to the foreman in charge of bending rails. The ordinates of the different curves should be marked on his sheet.

At the front the foreman in charge of the steel crew will know at a glance how many 29½-foot rails are to be laid on the inside of each curve. He should endeavor to lay these at regular intervals throughout the curve. If track is laid with even joints on the tangents and broken joints on curve, the difference in length between the inner and outer rails of the curve should be marked on the diagram. The rail should be cut in the material yard and the length of each piece and the station of the curve to be plainly marked on it so as not to delay work at the front.

FOREMEN SHOULD KNOW THE DEGREE.

18. Foremen in charge of curving rails should know beforehand the degree of each curve and the number of rails wanted for it, so as to have no delay in getting them to the front when called for.

WHEN LAID IN A SAG.

19. When a foreman lays a piece of track in a sag which he soon expects to raise up to a level surface, he can raise the track if the sag is not too deep without cutting the rails, by leaving the joints open as much as possible when laying the rails by keeping the bolts in the splices not too tight. Otherwise he will have to cut some of the lengths of the track because the track in a sag is longer than when brought up to the level surface.

CHANGE OF LINE.

20. In cases where a general change of line is made by moving a curve track inward several feet the foreman should have his men dig out all the material which is used for filling between the ties for the full distance covered by the new change in track line, so that the ties will not crowd against each other or injure the surface by raising up on top of the ballast. Before commencing to line the track, take out and set aside one rail length of the track in the middle of the curve. Then loosen up the track with a jack or lever bars and blocks. Start lining gangs at one or both ends of the curve and work toward the middle, moving the track toward the new line 12 to 20 inches, or as far as it can be pulled conveniently with one lining, without kinking the rails or splices. Continue thus until the opening in the middle of the curve is reached. Then go back and commence again as near the end of the curve as may be necessary, and work toward the middle as before. Repeat this process until the inside rail of the track has been moved beyond the center stakes for the new line, bringing in both ends of the curve alike. Then while part of the men are spacing and squaring the ties, and throwing in surfacing ma-

terial, etc., go over the ground with a handy gang of three or four men, and line the track to the center stakes. Do not cut the rails to fill up the opening at the middle of the curve until all the lining of the track is finished. Otherwise the rails may not fit after all the lining is completed. Lining from the ends of the curve toward the middle always forces the track to move forward toward the opening. By moving the track a little past the center stakes with the first lining, and then throwing it outward to its place when finishing the work, prevents buckling or jamming joints together and makes the track less difficult to handle. The latter operation stretches the track, and opens up joints that might otherwise have proved too tight for conveniently maintaining a good line in the future.

When the change of line is so great that the new line is some distance clear of the old track, it is sometimes a better policy to lay a new section of track throughout, than to try to move the old piece of track to the place with lining bars.

GOOD SIDE TRACKS.

21. It is a bad habit of some track foremen when putting in a side track to allow the work to be done in a careless manner. The track is surfaced poorly or not at all; rail joints are not square, splices are loose on the joints, with one and two bolts in them; ties are under the track in all shapes, at some places one foot apart, at others three or four feet. In fact, everything seems to be done as slovenly as possible, because it is only a side track. This should not be the case. All work on side tracks should be as good as on the main track, for several reasons; first, that train men may be able to do their work without accident to themselves or the company's property; next, that grain men and others may be able to move a car when

loading or unloading without having to call on every passing freight train to stop and switch it for them, and lastly, because a good, smooth side track will save burning so much coal, since an engine can switch a greater number of cars more easily than on a rough track. The little extra expense of making a good track, when laying it, is well repaid in the course of time.

TO STOP TRACK FROM CREEPING.

22. The best method to hold steel and to keep it from creeping down grades or from running ahead enough to throw track out of line or kink the rails, is to use the slot spikes in the splices. This can be done only where angle bar splices are used on joints. The advantage gained by putting the slot spikes in the splices instead of in the flange of the rail is that although the joint is held firmly in place, the slot spikes do not interfere with the contraction or expansion of the rails, and if the track is spliced and laid in this way and given the proper allowance for expansion, it will never give any trouble. Angle bars intended for use on heavy grades should have a base wide enough to allow holes being punched for spikes. Slots will in time become rounded or worn so much that spikes slip out and do not hold. This is impossible with angle bars having holes in them. They also keep joints in better gauge, especially on curves, because the rail must move the inside as well as the outside spikes before joint can spread.

The ties should be firmly tamped and rails properly spiked. Also if necessary a pair of angle bars can be cut into four pieces, thus making four angle bars with one hole in each. The bases of these can be drawn out so as to admit of a spike slot. Then by drilling a hole in the middle of each rail, where creeping occurs,

these short angle bars or stops can be placed on and firmly spiked to the tie. If considered necessary ties can be cut in two and placed upright in the ground, between the ends of the track ties, so as to be flush with the top of the tie. In preventing creeping one fact should be borne in mind; that is, if one rail is anchored, always do the same to the opposite rail, as then the full side of the tie is offered as resistance; whereas, if only one end is held in place the other end will move and thus the full effect will not be secured.

The ballast is to a certain extent an anchorage; also spiking has its effect. On double track roads the outside spike should be on the receiving side of the tie; on the inside, on the leaving. On single track roads the grades and traffic should control the placing of the spikes.

MAKING CONNECTIONS.

23. At any time when laying rails on main track or side track, never make a connection with a piece of rail shorter than ten feet. When you see that only three or four feet of rail is necessary to connect the ends of a piece of track, add the three or four feet to the length of the rail adjoining the space, cut two pieces of rail half the length of the total number of feet, and put them into the track to make the connection.

SHORT PIECES OF RAIL.

24. A piece of rail less than ten feet in length is of the most value to a railroad company when returned to the rolling mill. Except in cases where it is absolutely necessary to use short pieces of rail as at the ends of frogs, in the round house tracks, etc., the extra expense necessary to prepare them so that they will be perfectly safe in track (safety is the main point to be considered), will offset the difference in value between

old and new rails of equal lengths. A track foreman can generally avoid making a short connection, especially when laying old rails, by selecting lengths of rail that will leave him 15, 20 or 25 feet of space for connecting, as any of the lengths mentioned can be cut from a good 24, 26 or 30 feet rail that has been battered on the end.

THE STEEL CAR.

25. The men selected to work on the steel car in laying track should be strong, healthy, active men, all of whom speak and understand plain English. Men of different nationalities, no matter how good physically, should not be allowed to work together on a steel car. Where such is the case accidents are of common occurrence and the work does not progress as well as when the kind of men first spoken of are employed to do the work. The foreman on a steel car should be a man of energy and experience, when possible to procure such a one, and he should be equal, if not superior, to his men physically and intellectually.

LINING NEW TRACK.

26. When a new road is first laid the engineers put stakes along where the center of the track should be. These stakes are generally set about 100 feet apart, and a tack is driven in the top of each stake to show the correct center of the track. The man whose business it is to line the rails behind the tracklayers, always carries with him a small light wooden gage with the center marked on it. The manner of lining new track is as follows: The trackliner places his gage on top of the rails across the track over one of the center stakes. His men then lift the track to one side until the center mark on the gage is directly over the tack in the top of the center stake between the rails. This part of the track is then allowed to remain in that posi-

tion and should not be moved again. After the track-liner has put the rails in position at two or three center stakes, he proceeds with his men to put the rails between these points in a true line with them, which completes the work. Any carelessness on the part of the trackliner in the matter of putting the rails in their proper place at the center stakes is apt to cause trouble when the track has been surfaced, as it is often difficult for the trackman in charge of a section to get a perfect line on his track at places where the first track-liner left swings in it, because numbers of the center stakes are lost or moved out of position, during the work of tracklaying.

ONE OR MORE STEEL CARS.

27. When it is not intended to lay more than one mile of track per day, one crew and one steel car is sufficient. When it is necessary to lay from one and a half to three miles of track, two or more steel cars can be used to get material to the front, and a team of horses should be used after the second car is put on, to pull the load out and the empty car back. The regular steel car crew should never be taken from the front when two or three cars are used. They should only be required to bring back the empty car to meet the load, and turn the empty upon its side to let the load pass it. It is poor economy for tracklayers, when rushing the work, to have the steel car crew come back one-half mile or more to load steel.

HOW CONSTRUCTED.

28. The steel car should be light, strong and compact, and made of the best material, so that it can carry a heavy load and at the same time be easily handled by the crew working it. The wheels' tread should be at least eight inches wide, so that the car can pass over

loose and uneven gaged track without leaving the rails. A load of rails with the car off the track often causes considerable delay.

TRACK LAYING GAGE.

29. The gage used to hold the rails in place ahead of the steel car should be made of one solid piece of iron with a lip in projection to come down on both sides of the ball of each rail of track. This kind of a gage serves the double purpose of gaging the track, and of holding the loose rails in place until the car has passed over them.

When spiking new track the foreman should see that the gage is not placed too far away from the joint when the spike is being driven, otherwise if the loose end of the rail is bowed in or out the gage will be wrong.

A GOOD LINE NECESSARY.

30. After a railroad track has been properly surfaced the rails should be put in a perfectly true line. Few track foremen seem to give this part of the track work the attention it deserves, and even on first-class railroads it is seldom that anything like perfection in the line of track is attained. Of what avail is all the other work done on a piece of track if it be not in good line and gage? The surface may be perfectly level and smooth, but cars will ride badly over it at high rates of speed. The wheel following the crooked line and bad gage, cause the cars to dance from one side to the other almost as badly as if the surface of the track were rough, especially on curves, and a bad line or gage will soon make a track rough, because the heavy rolling loads cause the wheel flanges to strike the rails with great force, where the line is irregular.

There is no excuse for bad line or gage on track,

especially where it is ballasted, or foremen raise it up to surface it. All that is required is a little skill, a good, careful eye, and force enough to put the rails in place, all of which ought readily to be found on any section; while as a matter of fact, some of the track we see, looks as if all three of the requisites mentioned were almost entirely lacking.

A well-lined section is the best indication that the foreman in charge of it thoroughly understands his business, because a good line cannot long be maintained without also having a good surface on the track. In order to preserve the line of track as originally located, and to enable the foreman to keep a true line on the rails, permanent stone monuments should be set in the ground at convenient distances along the center of the grade, of a double track railroad, or on one side of a single track, and the top of each monument should be chiseled square or capped with iron or steel so that a gage may be tried at any time and show the correct distance between the monument and the nearest rail of either of the tracks. These monuments could also be made the standard from which to take levels when surfacing track, or when ballasting track out of a face, by having the grade levels marked and numbered on each monument; any of the figures on one monument designating the same level on all of them.

CATTLE GUARDS.

31. For a good, safe cattle guard an iron or steel surface cattle guard, which can be put in without excavating under the track to a greater depth than the bottom of the ties, and which will at the same time prevent cattle or other animals from coming upon or crossing it is just what the railroads need, and are gradually replacing all the old pit cattle guards. The

chief objections to the common timber cattle guards are that those which are constructed by excavating a hole in the ground and spiking the rails along the top of a single stringer over this hole makes a trap for cattle to fall into, and that if a car wheel or truck is derailed before reaching one of them there is liable to be a very disastrous wreck.

Cattle guards constructed on the same principle with track or bridge ties along their tops only lessen the danger to some extent, because the ties, if not very close together, are liable to break under the wheels, and if cattle attempt to cross such a cattle guard, which is often the case, they sometimes fall through, and in this position they are liable to wreck a train, and cannot extricate themselves without assistance.

An iron surface cattle guard can be put in and maintained at a less cost to the railroad companies than one made of timber and constructed in the usual way, and its use must result in economy, in keeping a good, smooth track at points where the pit guard would be heaved up by frost in the winter and required the service of section men to shim and repair it very frequently.

LIST OF TRACK TOOLS.

32. List of track tools for a section of five miles, foreman and crew of five men:

Adzes	2	Hatchet	1
Axe	1	Lanterns, White	2
Hand Axe	1	Lanterns, Red	2
Tool Box	1	Lantern Globe, White	1
Water Bucket	1	Level, Track	1
Brooms	3	Level, Boards	1
Claw Bars	2	Levels, Blocks	2
Lining Bars	4	Clay Picks	6
Raising Bar	1	Tamping Picks	6
Tamping Bars	6	Pad Locks	2
Chisels	6	Rail Tongs	2

Hand Car	1	Scythes	6
Push Car	1	Scythe Snaths	6
Oil Cans	3	Scythe Stones	6
Water Can	1	Shovels	6
Chairs	2	Scoop Shovels	4
Dippers	2	Single Rail Truck	1
Ratchet Drill	1	Hand Saws	1
Drills	6	Crosscut Saw	1
Red Flags	2	Rail Saw for every 50 mls.	1
Green Flags	2	Jim Crow for every 50 mls.	1
Track Gages	2	Torpedoes	12
Grind Stone	1	Track Jack	1
Grub Hoes and Mattock	3	Tape Line	1
Pick Handles	6	Track Lever	1
Axe Handle	1	Tie Square	1
Adze Handles	2	Wheel Barrows	2
Hammer Handles	6	Track Wrenches	4
Spike Hammers	4	Monkey Wrench	1
Sledge Hammers	1	Water Keg	1
Napping Hammer	1		

LOCATING WAGON CROSSINGS.

33. In States where the law is such that the public has a right to use the section lines as public highways, it is a good policy for those in charge of building new railroads to have all the necessary grading done at such points as there is a probability of locating grade crossings in the near future. The work can be done with less expense when the roadbed is in course of construction than at any other time.

WHERE TO SPIKE THE PLANK.

34. When locating public or private plank crossings on their sections, foremen should, whenever it is possible, spike down the plank at the center of rail, because if the crossing is spiked down where a rail joint comes in the track, when the joint gets low it cannot be raised up to surface without removing the plank to do it, and for this reason is often neglected.

A COMMON PLANK WAGON CROSSING.

35. Seven 3x10-inch planks will do for a common

public wagon crossing. One plank is to be used on each side of the track outside and spiked close up to the rails. Five plank are to be used in the center of the track, leaving a space for the wheel flanges next to the rails on the inside. About five inches of the ends of the crossing planks should be dressed off with the adze, leaving a slanting surface, which will enable any objects which strike the end of the plank to pass over them without tearing the plank out of place.

For private use a cheap and efficient crossing may be made by cutting two ordinary 16-foot plank in two

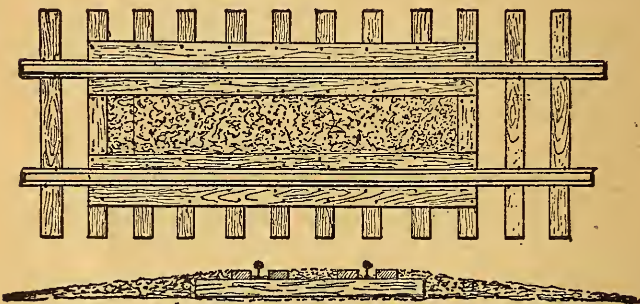


FIG. 2.

and these four pieces, each 8 feet long, will make a good farm crossing. Some may object that such a crossing is not wide enough, but as the tread or gage of a farm wagon does not usually exceed 4 feet 10 inches, such an objection carries no weight. By the use of short plank, rail joints may be avoided in the crossing, and the great saving effected in plank is worth consideration.

A STANDARD HIGHWAY CROSSING.

36. A standard highway crossing on the C., M. & St. P. Ry., is made by using one plank along the outside of the track rail and only one plank along the

inside, and at each end between the inside planks is spiked a short piece of plank forming a kind of box, which is the filled with earth, broken stone or cinders. (See. Fig. 2.) This kind of crossing where it can be used saves considerable lumber and is both durable and economical. The C., R. I. & P. R. R., and some other roads use a track rail in some of the crossings, instead of the inside plank. The rail is laid on its side, with its head against the web of the track rail, thus forming a channel for the wheel flanges to run in. It is bolted to the track rail near each end and its ends are then turned in towards the center of the track and all the space between both sides is then filled up level with broken stone or other material. This style of grade crossing has some advantage in being so easily kept in repair and not requiring the services of trackmen to clean the ice and snow from the flange way in the winter season. But the item of first cost is considerably more than other crossings on account of the large amount of metal in the rail.

It would undoubtedly pay to have a rail specially manufactured of a much lighter and slightly different pattern which would accomplish the same results in every way as well as a track rail and thus remove the chief objection to this style of grade crossing which could be made the best and most economical of any of those here mentioned.

CHAPTER II.—SPIKING AND GAGING.

HINTS ABOUT SPIKING.

1. Track should always be kept full spiked and in perfect gage. In order to keep it in perfect gage one of the standard width should be used, and when track is spliced the gage should be square across, about six or eight inches ahead of the tie spiked, and remain between the rails until the tie is spiked. The outside spike should not be allowed to draw the rail too tight on the gage or to be driven loosely, either of which will affect the width of the track after the gage is lifted. When gage is tight, start inside spike first, when loose, the outside spike first. Bad gaging detracts from the looks of an otherwise good track, makes track easier to knock out of line and down below surface, and is also dangerous and the direct cause of numerous wrecks. To be driven properly a spike should rest upon its point almost perpendicularly, when receiving the first stroke, which if delivered right, will leave the spike perfectly straight up and down. The spiker should then try to deliver each stroke in such a manner as not to draw the spike in any direction until about the last stroke, which should draw the head of the spike toward the rail and down to the flange, both at the same time. Care should be taken never to strike the last blow on a spike too hard, as this either cracks the head or breaks it off, rendering the spike in either case useless.

PULLING SPIKES.

2. To draw a spike in frosty weather, or to draw

a spike out of an oak tie at any time of year, tap the spike down on the head with a spike maul once or twice, before attempting to pull it out of the tie with the claw bar. In most cases there will then be no difficulty in pulling the spike without breaking it. Tapping the spike down with the maul loosens its hold on the wood of the tie and makes it easier to remove. If an opposite course is pursued and trackmen try to pull spikes without doing as above directed, a great number of the spikes will break off under the head.

WHERE TO DRIVE SPIKES.

3. The spikes should be driven about two and one-half inches from the edge of a track tie. Both inside spikes should be driven on one edge of a tie and both outside spikes on the other edge in order to prevent the tie slewing and also to assist in holding the rail from creeping. The spikes take a better hold in the wood of a tie, and support the tie under the rail better when driven thus. An oak tie will split open on the ends in frosty weather if the spikes are driven in the center of the tie. The tie, so split, will rot much quicker, and will have to be removed from the track sooner than the tie which remains whole. Another reason why the track spikes should be driven in the sides of the ties is because the wood in the center of most ties is softer and may be decayed, while as a rule, the sides of the ties are sound timber.

GAGING TRACK.

4. Section foremen should make an effort to gage all of the track in their charge once a year if possible. Early in the winter, and before general track work begins in the spring are the best times to gage track, because at such times, on northern railroads, there is generally less of other work to be done than during

the balance of the year. A section well gaged once can easily be kept in that condition ever after.

Before commencing to gage track out of a face, the foreman should get all the necessary tools in good condition, have ready two spike mauls, two claw bars for pulling spikes, a good sharp adze for dressing a surface for the rail on the ties, two standard gages, one for gaging the track and one for testing the gage of track before pulling the spikes; also a good supply of track spikes and wooden plugs to put in the old spike holes.

If there are any very bad places on the section, begin gaging these first, but if the average is the same throughout, it is best to work from one or both ends continuously, marking every evening where you leave off work for the day.

When you arrive on the ground to commence work, take out all short kinks on the line side and spike the rails to the line, and have your men knock down all loose spikes on that side of the track before bringing the opposite side to gage.

The foreman should take one gage and test all the track ahead of the men gaging, and mark all ties where spikes have to be pulled. Keep only enough spikes pulled on the gage side of the track to make it handy to adjust the rail to place ahead of the gage, and have the track always ready to close up for trains to pass.

Have one of the men move the rails to place ahead of the gage with a lining bar, and do not try to draw it with the spike more than a quarter of an inch.

Do not spoil or waste any of the old spikes that are fit to be used a second time, and if they are oily or greasy throw a little dirt or sand on the head of the spike when you tack it in the tie: This will prevent

the spike maul from slipping off the spike when driving it. Measure the gage and be sure it is of the correct length, four feet eight and one-half inches, and if it is an iron gage and the end lugs touch the joint fastenings, grind or file them off, tapering so that nothing but the rail will touch the gage when placed across the track.

If the gage of track on a section is not very bad, a foreman and two laborers will do an average of one-sixth of a mile per day. Gaging and spike-lining a section of track well during the winter, besides improving the track at that time, will enable the foreman to put a first-class line on the whole section during the following summer, and will materially lighten his other work.

LOOSE SPIKES.

5. A section foreman should be particular to keep all loose spikes on his section driven down in the ties, and tight against the rails. The majority of the foremen are not so careful in this respect as they should be. Loose spikes in soft ties, where track is not level, leave the rail at that place liable to be turned over and cause a wreck. You cannot keep track in good line with loose spikes, and green men, tamping loose ties when surfacing, lose considerable time holding up the ties. These often spring up the center of the rail, spoiling the surface and making it necessary to go over the work a second time.

RESPIKING TIES.

6. Whenever it is necessary to pull the spikes out of ties in the track, changing rails or at other repair work, and you find that the old spike holes in the ties will do for spiking the second time without changing the gage of the track, do not use a fresh place in the

ties to drive the spikes, but plug the old hole with a chip or tie plug and drive the spikes as they were before pulling. Ties soon rot and break off under the rail where spikes have been driven in different places, while the balance of the tie may be good, sound wood.

TO KEEP TIES SQUARE ACROSS THE TRACK.

7. All ties should be spiked in a position square across the track, especially when laying new track, which is to remain some time without being surfaced up or ballasted. The spikes should be driven in the ties in such a manner that they will hold them in place, otherwise they will be twisted out of their proper position and affect the gage of the track. Spikes should be driven with both inside spikes, or the two outside spikes, on the same edge of the tie. This prevents the ties from twisting out of square.

TRACK NOT FULL SPIKED.

8. When any side track or main track is not full spiked on the inside of the rails, the foreman in charge of it should examine closely all places where the ties have commenced to decay, and when he finds a double or full spiked tie rotted, should remove the inside spike in the rotten tie, and drive it inside the rail in the next single spiked tie. This is very important in the winter, or when the rotten ties cannot all be taken out of the track, because, where two full spiked ties are rotted close together, and the track is only half spiked inside the rails, the distance along the rails to where spikes are effective is from eight to twelve feet.

This is one of the best arguments in favor of full spiking all track, and applies also to side tracks.

SPIKING BRIDGE TIES.

9. Holes should be bored in bridge ties along side where the flanges of the rails would come, for the track

spikes to be driven into. The holes should be one-sixteenth of an inch smaller in diameter than the spikes used. Making the holes in the ties a little smaller than the spikes, allows the wood to close up the hole around the spike when driven, and gives the spike a more secure hold upon the tie than if the hole was bored the full diameter of the spike. There is always danger of spliting bridge ties when the track spikes are driven into them without first boring the holes, because the grain of the wood seldom runs lengthways of the ties, and the work of repairing can always be done easier where the holes have been bored for the track spike, especially in oak ties.

There should be in general use a track and guard rail gage combined, made by putting a lug or projection on one end of the gage inside the track rail. This lug should be the proper width to fit between the track rail, and guard rail opposite the point of the frog, in order to gage the wheel channel to a uniform standard on all switches.

CHAPTER III.—GENERAL SPRING WORK.

OVERHAULING TRACK IN SPRING.

1. When the frost is leaving the ground in the spring track foremen should remember to do all the little odd jobs which have been left over or neglected during the winter, on account of frost and snow. Following are some of the most important rules:

Clean up the station grounds and tracks, and pile up neatly all track material or other material which may be scattered about the premises.

Gather up all trash, cinders, old straw and manure from company stock yards, and haul it out to fill up low places or holes on the right of way, or burn it, if necessary.

All switches and leads should be spiked into proper gage and line, and battered rails replaced by good ones.

Guard rails and frogs should be examined, and any defects in them remedied, or new ones ordered to replace them.

All track ties on hand should be loaded on cars, and distributed along the section, where they would be most needed on the track, to have them ready when the time comes for putting them in.

All loose boards on snow fences should be nailed up, and right of way fences should be examined and repaired, especially in low places or where they cross water courses.

Loose plank in wagon crossings should be taken

up and cleaned underneath, and ragged or split ends should be dressed with adze, and then respiked to place.

The approaches to all highway crossings should be filled and fixed, so that teams would have no trouble in crossing the track.

All fence posts, crossing signs, whistling posts and telegraph poles, should be put in correct position and tamped solid.

Shimmed track should be watched, and very thick shims should be replaced by thinner ones as fast as the heaving goes down, and all shims should be removed from track as soon as it is possible to spike the rails to the proper surface.

Go over the section and tighten up all loose bolts, putting on them nut locks or washers where necessary, and put in good bolts in place of broken ones.

Look out for soft places in your track, and repair to the best of your ability, notifying train dispatcher and roadmaster when any such places become dangerous, and make ditches in wet cuts to carry off the water, widening them or increasing their depth as the frost goes out.

The different kinds of work mentioned above, if looked after now, will enable the track foreman to make much better headway when the rush of summer work begins.

WASHOUTS.

2. The time of year is now at hand when thawing, snow and rain, combine to increase the quantity of water above the surface of the ground, and as the frost goes out of the ground but slowly, at best, there is always danger to a railroad from the accumulation of too much water at one place. This may damage the track by undermining or washing away its supports; or by loosening the earth on hillsides along the track,

it may cause quantities of earth, stones, or trees to fall or slide upon the track.

Section foremen should keep a sharp lookout for washouts at all points on their sections.

Ditches should be opened up, and water-ways cleared of all obstructions, and all track, trestles, bridges and culverts should be examined every day without fail. Where there is liable to be any trouble the section foreman should remain out with his men day and night, and do all in his power to keep the track safe, always remembering that upon the vigilance of himself and men, may depend the lives of trainmen and passengers.

In case of a dangerous storm the foreman, if his section extends both ways from his headquarters, should send a man over the short end of it with instructions to reach the section limit as soon as possible, and to remain there and use the necessary signals to flag trains should he find anything dangerous on the way out. The foreman should go as rapidly as possible in the opposite direction towards the other end of his section, leaving a man a sufficient distance ahead of the first break or washout to flag trains following, in case they should be able to get over the other end of the section safely. The foreman should note the location and dimensions of all places needing repair; but he should not stop to do any work until the end of the section is reached, and the men have each been posted to remain and flag trains for all the dangerous places found.

The foreman should then go to the nearest telegraph office and report jointly to the roadmaster and train dispatcher, stating fully the condition of the track on his section, giving location and dimensions of all breaks in roadbed or track, bridge and culvert

numbers, number of bents destroyed in bridges, and any other information which would be valuable as a basis from which to calculate the amount of material or force necessary to put the track in good condition.

This will insure the safety of trains, and enable the train dispatcher to hold them at convenient points until the track is passable, and the roadmaster and bridge men will be prepared to get the work done without delay.

After reporting the condition of your section you can go to work repairing small breaks at points where a large gang of men could not work to advantage, but do not call away your men who are flagging at dangerous places, until you are positive that there is no possibility of trains passing there, or the roadmaster has arrived with extra force to protect and repair such places.

Instances have occurred where foremen have stopped to repair the first bad spot found, and allowed trains to run into other bad places on their section. It is always the foreman's duty first to protect those dependent upon him for safety, and then to notify superior officers of the condition of their sections. If the whole of the track on your section is safe, send report to that effect so that trains will not be delayed by slowly feeling their way over it.

REPAIRING TRACK.

3. When track is being repaired which has become rough or uneven, all low places should be brought up to surface and both rails on straight track should be level, and on curves the elevation should be uniform to suit the degree of the curve.

ON LONG SECTIONS BALLASTED WITH EARTH.

4. When a section is long and a foreman is allowed

only a small force of men to keep it in repair, it is not a good policy to surface a track out of a face (as should be done when putting in gravel). A section foreman, if forced through necessity to get up to surface a rough piece of track with a small force, can do so in a short time by adhering closely to the following instructions, which are only intended for section foremen with long sections, a track laid on clay, and a very limited number of men for help. For example, we will say a foreman is allowed only four men on a ten-mile section. Select the roughest part of your section, give one man a shovel, another the track level or jack, keep these two men with you; the man with the shovel to dig block hole for lever, and assist in raising the low places wherever it is necessary. When you find a place that needs raising, stoop down and sight the rail. Take an estimate in your mind of how low the place in the rail is which you have sighted below the proper surface, also count the number of ties running each way from the lowest point. Then tell your two men to raise that part of the rail which is the lowest, and when it is up about four or five inches, or so high that dirt can be easily thrown under, take your own shovel and throw under each tie the exact amount of dirt that you think is necessary to bring it up to a proper surface. To do this work properly, so that it will hold track up for some time, the dirt should be thrown under the ties a little at a time, and as far as it can be put towards the center of the track. Because, if the dirt is thrown only under the ends of the ties, a hole is left under the middle of the tie inside of the rail, which will fill with water when it rains and become worse than before. But if the rules here laid down are followed out properly, a section foreman of ordinary intelligence, after a little practice, may become an expert at this kind of work,

and make almost as good a track as by tamping it in the regular way.

When a section gets very rough the ordinary method of repairing track must be dropped for the time being, and in the case mentioned, viz.: a very long section, rough track and small force, if the foreman can pocket his pride and risk being called a corn husker, he may, by following the above plans make a wonderful improvement in his track in a short time. A foreman can get over about one-quarter of a mile in a day, in good weather. It is best for a man who has never tried this method to practice on very low joints. As to the other two men of the four, they should be left to follow up, dressing the track, filling the block holes, etc. About two hours before quitting time the foreman should stop raising, take the four men, and line up the piece of track which he has raised, leaving a perfect line on the line side; he should then let two men dress the center of the track, while the other two take a gage and spike maul, and bring all crooked places in the gage side to the proper line and gage. After a section foreman has gone over his whole section in this way, the track will be greatly improved and will look as good as the average dirt surfaced road. Now supposing the foreman has got so far along with his work as to have his section all surfaced up in the aforesaid way, he can go back and pick up small sags wherever he can procure enough dirt to bring them up to surface. The sags should be surfaced out of a face and tamped and allowance made for track settling. When a rail on one side of the track is sighted the section foreman should use the spirit level to bring the opposite rail, which is raised up to surface.

DRESSING MUD TRACK.

5. When you fill in track with dirt, have your men

throw the material in the center of the track. It is much easier to dress it then than if it is thrown along just inside of the rail in a slovenly manner. Round the dirt off, leaving the center about two and a half inches above the tie. Cover about two feet six inches of the center of the ties between the rails, sloping the dirt from the center so that a shovel blade can easily be passed up under the rails between the ties and allow the water to run off. Continue the slope until it runs out at the bottom of the ends of the ties. Outside of the ties the shoulder should slope one and a half inches to the foot, as far as the edge of the embankment. In a dry country the filling may be allowed to come up higher between the ends of ties.

LINING OLD TRACK.

6. When a railroad is in operation the track should be kept in perfect line at all times. Nothing contributes more to the smooth riding of a train than a true line of rails. The foreman, when lining track, should do as much as possible with his back to the sun, because in that way he gets the best view of the rails. It is also necessary to look at the track line from the opposite direction, especially when lining across a sag, and also at end of curves. A common fault is in lining the last four or five rails on tangents to throw the track too far out. Very few trackmen can line track perfectly by going over it only once, unless they are experts and have perfect sight. Always stand as far away from the place to be lined as your sight will allow, and train your men to line by the motion of your hands, when first putting the rails in place. By standing too close to the place to be lined, you are liable to throw a swing to one side of the track. This is a fault of many foremen and should be avoided. If

you have a section which the previous foreman left in bad line, show your ability by remedying its defects in that particular every time you have an opportunity. If a foreman has some track on his section which has settled down and out of line, where the ground is wet or soft, and he has not the force of men necessary to move it, the work of putting it to place can be done with a small gang, by pulling the spikes out of two or three ties in a rail length at a time, and using the lining bars on top of the dead ties under the rails, thereby gaining a solid foundation to rest the bars upon, and much more leverage than could be got with the bars in the ground. After the track has been lined to place, the dead ties can be shifted to their proper positions or the rails can be spiked down on them temporarily as they lie. When the track has a tendency to slip back the dead ties act as a brace to keep it in position. Very heavy track can be lined over to where it is wanted with a force of only two men by using a track lever or long bar on top of a block of wood with a rounding top surface. Place this block underneath the rail on that side of the track towards which it is desired to line it to. By pulling down on the lever a lifting pull is exerted, which draws the track towards that side, and with the assistance of another man on the opposite side of the track pulling in the same direction with a common lining bar, the track can be lined to place. Foremen whose eye-sight is not equal to the task, can assist themselves when lining long stretches of track by placing clods of dirt or other small objects along on top of rail joints where the track has to be moved. It is much easier to get the small, dark objects into a true line, on account of the contrast between them and the rail, than it is to line perfectly a long stretch of rail, with its brightly polished and unbroken surface. Some

of the instruction here given as to track lining may seem unimportant, but a knowledge of how to act in certain cases is often the want of a trackman, and to the young man not much experienced or learned in the track service, they will be found a valuable help.

BOLTS THAT ARE TOO TIGHT.

7. Some trackmen think that all bolts should be kept as tight as it is possible to make them. But it is an error any trackman will fall into, until he is convinced to the contrary. There are several kinds of nut locks for track bolts in use on the railroads throughout the United States, the majority of which are devised for the purpose of locking the nut, and, at the same time, allowing the rails to contract or expand after the bolts are tightened without danger of breaking them. But the section foreman and his men come along, and tighten up all the bolts on the section, even if they can only make a quarter of a turn with the wrench. In fact, many foreman add pieces to the ends of the track wrenches, so that the men may be able to get more leverage, and as a result of their labor everything on a joint in the shape of a nut, lock, or washer, whether it be iron, or steel, or wood, or rubber, has every particle of spring or elasticity taken out of it, and the bolts all stand ready, the moment a train passes or a change in the temperature comes, to pop off, as they break like so many candy sticks and numbers of them can be found along the track. Many of the nut locks which are used as above are no longer of any value except as washers to cover a few threads of the bolt. A joint with either four or six bolts in it, with a spring nut lock on each bolt, should have the nuts tightened just enough to get the full force of the resistance of the material used for a washer between

the nut and splice. A comfortable twist of the track wrench with the hand, after the nut is run up to place will be found sufficient force to use when tightening bolts. When bolts are tightened in this way and there are angle bar splices used on the rail joint slot spiked to the ties all danger of the bolts or rails being injured is avoided, and the rails can contract or expand without track creeping. A slot spike through the rail flange in a tie with the bolts in the joint as tight as they can be made will either break the bolt or kink the rail near the spike, or throw the track out of line in hot weather. To prevent trackmen from breaking bolts when tightening them, track wrenches should not be made longer than sixteen inches for $\frac{3}{4}$ in. bolts.

REMOVING OLD TRACK BOLTS.

8. When removing old track bolts from a joint splice, foremen should not allow their men to strike the thread end of the bolts with a wrench, a hammer, or any tool that would injure the bolt. Such usage spoils the bolts for further service. Nor should foremen allow their men to break the bolts out of a joint except in a case of emergency, such as to get ready for an expected train, or when a large gang of men, ready for work, might be delayed too long by waiting to remove a few bolts with a wrench. The nut should not be entirely removed from the bolt while in the splice until the bolt is loosened. A light tap on the nut when nearly off will loosen the bolt in the splice without injuring the thread. The threads of the old bolts should be oiled, and then nuts put back on the bolts again, so as to have them ready to use when wanted. By way of information it may be stated that a new bolt costs about 1c and if they are on hand no time should be wasted trying to save an old, rusty, battered bolt.

CHANGES OF TEMPERATURE.

9. All sudden changes of temperature affect the bolts on account of the expansion or contraction of the rails. This is most noticeable in the spring and fall of the year. Foremen should not neglect to tighten up the bolts when they begin to rattle as trains pass over, or at any time when it is necessary. Always remember that loose bolts make low joints, and increase the labor of track repair.

LINE OF BRIDGES.

10. Section foremen should be particular to keep the rails on all bridges in good line, especially when they heave up or out of line in winter; also keep a good line and surface on the approaches.

NUT LOCKS.

11. There is hardly a railroad now in operation that is not using nut locks of some form, the best known of which is the Verona Nut Lock, there being over 270 millions in use. The utility of a satisfactory locking device for nuts is unquestioned, since its application saves its cost many times over in reduced labor tightening bolts; and the saving effected in preventing nuts from working loose insures also the required stiffness in joint fastenings, and prevents their wear.

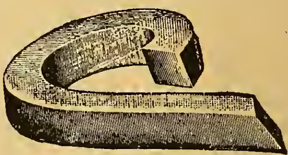


FIG. 3.

There have been numerous kinds of nut locks devised and manufactured, some possessing real merit and more having no value at all; but in point of simplicity and adaptability the Verona Spiral Nut Lock has won a place as a general favorite. They are well-tempered and elastic, and after the bolts give out and

are thrown in the scrap pile, the nut locks can be put to use on new bolts. Fig. 3 illustrates the device.

REPAIRING BRIDGES.

12. All repair work on bridges should be done by bridge men or those who have charge of such work. Section foremen should not attempt to raise up stringers or caps on bridges, or do any other work on bridges for which they have not the proper tools or the necessary practice to perform. In absence of bridge carpenters section foremen can shim up the approaches of bridges when out of surface, or put blocking under stringers which have become loose on pile bridges, etc. All shimming should be done on top of ties when practicable.

THE ENDS OF BRIDGES.

13. The ends of all pile or frame bent bridges should be planked and filled in with ballast, and all dump ties should be tamped solid, up to the ends of the bridges. Whenever it is practicable the end of a bridge and the dump should meet under the center of the track rails laid over them, because when a rail joint comes on the dump close to the end of a bridge, it is always more difficult to keep the track up to a good surface than if the center of a rail were there.

CHAPTER IV.—DRAINAGE.

DITCHING.

1. In order to ditch a cut properly, a foreman should take measurements from the rail to the bottom of the face of the cut, at different places along the cut, and ascertain at what average distange from the track it will be best to have the back of the ditch. This is very important, because in the majority of cuts on a railroad the line of face is more or less irregular and not truly parallel to the track, and the best distance from the track for the back of a ditch is that distance which will give a good ditch without moving too great an amount of material. After a foreman has decided what width the ditch should be, he should line it with the shovel or drive stakes along the back of it, for his men to work by; otherwise they will be apt to make it crooked. Nothing is more unsightly than a crooked ditch, and it will fill up much quicker than a straight one. The ditch should always be a little deeper at the lower end of the cut, and gradually grow shallower as it goes up grade. If you ditch parts of two or three cuts on your section at different times, each of the cuts will have some time to drain off, the material in the ditches will be dryer and in better condition to work in, and men can do more than if they were kept in one very wet cut all the time. Where water leaves a cut through a ditch, the ditch should be well turned off from the track. Always carry the discharge end

of a ditch so far away from the track that there will be no danger of water from the ditch washing out the embankment under the track. Foremen should always select for ditching a time of the year when the weather is not fair enough to do other track work. Some foremen use very poor judgment in this matter, sometimes spending two or three weeks in making a ditch during good dry weather, while there is a great amount of bad track on their section which needs to be put in good repair.

FORM OF DITCHES.

2. The width of a cut and the slope of its face on each side of the track must always govern, to a certain extent, how far from the track rails to have the back

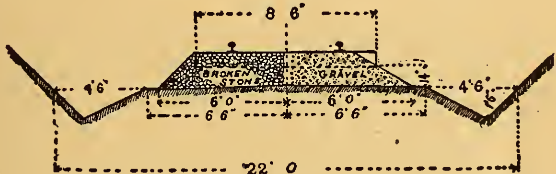


FIG. 4.

of a ditch. All railroad cuts should be open so wide when the track is first laid that there will be room to make all ditches a uniform distance from the rail. A ditch should be deep enough to thoroughly drain the track, and the distance from the rail to the back of it should be in proportion to the depth of the ditch, giving the water an easy fall from the track and free passage through the ditch, so that there will be no danger of its washing the shoulder of the grade, or undermining the track. Deep ditches close to the track in a cut, soon weaken the foundation, and wash away the ballast outside the ties, especially where the ballast is sand or gravel. The bottom of a ditch should

be from eight to ten feet from the rails where the grade width will allow it, and should also be two feet below the bottom of the ties.

Fig. 4. shows formation of ditch on the L. & N. Ry., measuring 8 ft. 8 inches from rail to back of ditch. Some roads form their ditch as far as 12 ft. from nearest rail, which, however, is exceptional.

SLOPE OF DITCHES.

3. When track is ballasted with dirt the slope should commence in the center of the track two and

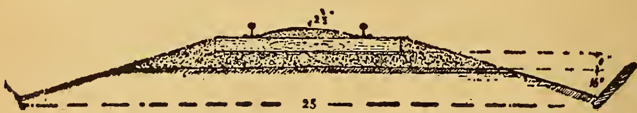


FIG. 5.

one-half inches above the ties, and run out for a distance of seven feet, falling at the rate of one and one-half inches to the foot. From this point, which is three feet outside the ties, and two inches lower, the incline should be greater, about in the proportion of four inches or more to the horizontal foot. See Fig. 5.) Ditches which are made to conform to this shape are

FIG. 6.

easily cleaned out. They are quicker made, and there is much less dirt to be moved than when the ditch is made dish form, because the water is always thrown away from the track. It is a mistake to run the slope from the bottom of the ends of the ties, directly to the back of the ditch, as some trackmen do, because when the track is raised up to put ballast under it, the inclina-

tion of the foundation beneath it will be too sharp to protect the ballast from wasting or washing away. If a track is ballasted with gravel, the slope towards the back of the ditch should commence about two feet outside the track rails, as shown in Fig. 6, the ballast at this point being nearly level with the base of the rails. This is subject, however, to considerable variation, and hardly two roads agree exactly as to what is the proper form of roadbed, slopes, ditches, etc. Figs. 7

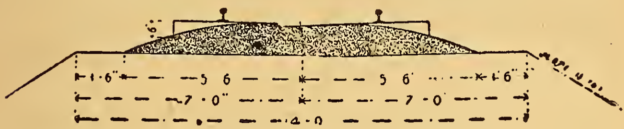


FIG. 7.

and 8 show the practice on the Great Northern Railway on gravel ballasted single track road. It is seen that the ballast slopes in the cut from the rail to within 6 inches of berme, and on a fill from the rail to within 18 inches of berme width of roadbed, being 3 feet greater on the fill than in the cut. Another modification is shown in Figs. 9 and 10, showing method in vogue on the Union Pacific Railway. Note that slope

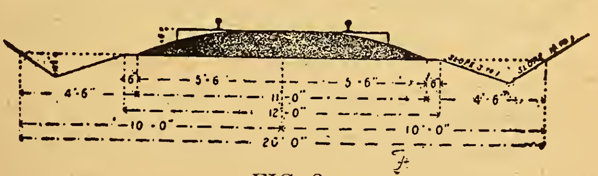


FIG. 8.

of ditch adjacent to track is one in five, while slope away from track is one in one.

GRADE OF DITCHES.

4. If a cut is level throughout its length, the ditch should be deeper at the ends than at the middle. Where

the grade of a cut descends towards the ends from the center, the average depth of the ditch may be the same throughout the cut. Trackmen should always begin to ditch at the lower end of a wet cut, and finish up as they go. The piece ditched every day will help to drain off the water behind them. The principle governing

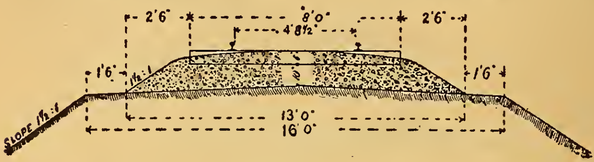


FIG. 9.

this is that a ditch must have fall in the direction the water is to drain.

CLEANING OUT DITCHES.

5. No old ties or other obstructions should ever be allowed to remain in the ditches along the track. They should be cleaned out thoroughly every fall and the last thing before winter sets in, so that during the

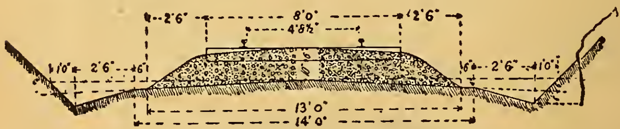


FIG. 10.

continuance of the spring rains or while snow is melting, the water can pass off freely without injuring the track. A small ditch made with a plow along the top of the side of a deep cut, and near the edge of its face, will carry off the surface water, and protect the side of the cut from washing into the track ditches and filling them up too rapidly.

If the track through a cut has a uniform falling grade sometime advantage may be taken of it to turn

any surface water flowing near the upper end down through the ditch and thus keep it scoured out. There is no danger of injury to the track if the ditch carrying the water to the upper end of the cut is not made too large.

A DITCHING RULE.

6. A simple device like that shown in Fig. 11 is very handy for foremen to use when ditching. It can be made as follows: Use for the long piece a straight edge 1x4 inches, twelve feet long. For the

FIG. 11.

short cross-piece B, use a piece of board 1x3 inches, four feet long. On one end of the long piece fix a piece of sheet iron, C, twelve or fourteen inches long, double it, and bolt the ends of it through the wood, leaving a space through which the short piece, B, can be passed freely. A hole should be bored through the sheet iron, so that a set screw or a bolt can be used to secure the short piece at any distance from either end of it. The cross piece, B, of the ditching rule should be set so that the back of it will be at the proper angle for the back of the ditch, and upon one side of it should be marked the distances by which to regulate the depth of the ditch. When in operation, one end of this ditching rule, D, should rest upon the nearest track rail, and at the other end the material should be removed from the face of the cut, until the cross piece, B, rests in proper position to shape the ditch. Then, by trying the spirit level on top of the longer piece, and adjusting the cross piece to the required depth, the bottom

level of the ditch can be carried uniformly throughout the length of the cut, if the track is in true surface, without any change in the rule. Foremen should fit the rule to place at distances of a rail length, or less, and the men will have a guide to work by, and can cut the ditch correctly without any additional labor. A marker can be put on the long piece, which will show where the ditch slope commences outside the ends of the track ties. If it is desirable to lower the ditch, say twelve inches in as many rail lengths, it is only necessary to let the cross piece, B, down one inch every thirty feet, at the same time keeping the long piece always level on top. In like manner by shortening up the cross piece the ditch bottom can be gradually raised or made more shallow.

TRACK DRAINAGE.

7. A thoroughly good drainage is one of the most essential features of a first-class track, to accomplish which, all the water which falls upon the track or adjoining land should be conducted through ditches, culverts, bridges, or other channels to the nearest running stream that will take it away beyond possibility of injuring the track.

These channels for conveying the water away from the track should be sufficiently large to perform the duty required of them as well during a freshet as when only an ordinary amount of water passes through. At all marshy or low places where water remains standing along side of the track, openings should be made high enough above the water to insure a solid, dry roadway. The embankment should also be rip-rapped along the sides, if there is any possibility of strong winds or rapid streams forcing the water against it and washing the material away.

In this connection it should be remarked that where

musk rats or minks are plentiful and cause damage to the track by burrowing under it, a good heavy coating of cinders and slag along the sides of the embankment is a most effectual protection against their depredations. The cinders form an acid in the water, besides they are too sharp for the animals to burrow through, forming thus an admirable remedy against their ravages.

In deep, wet cuts where the material has a tendency to slide, the roadbed should be widened out much more than at any other point, and the face of the side of the cut should be made with a very gradual incline from the top of the cut to the track. If it will grow some grass all the better.

The work of widening cuts and roadbeds can be done cheaper and to better advantage before the track is laid than afterwards.

The bottoms of ditches which run alongside the track, through a cut, should be carried not less than ten feet from the rails on each side, and they should be as far below the bottom of the track ties as it is possible to have them, and retain a nicely proportioned incline from the ends of the ties to the back of the ditch. Open ditches or tiling which are too close to the track, or not deep enough below the track ties, are only a make-shift and a hindrance to maintaining a good, dry track. Coarse stone makes a good foundation in a wet cut, if laid beneath the ballast into which the ties are imbedded (but they can be dispensed with, where the track can be raised up above the mud without spoiling the surface or grade standard). In fact, this latter is the most economical method (after a track has been laid) of draining a track and making a good ditch at the same time. Briefly stated, to drain the track in a cut, the same conditions must exist, as

nearly as possible, as where the track is laid in ballast on a good, solid fill or embankment, several feet above the surface of the ground the same as where there is no cut.

The incline of the sides of the embankment should be a natural slope, with no abrupt angles. No earth embankment can be prevented from washing without artificial means where the incline is so steep that vegetation will not grow upon it.

Instead of box or open culverts of timber, iron tubing or vitrified culvert pipe of a sufficient strength should be substituted, this tubing or pipe to be faced with masonry at both the inlet and outlet of the pipes on each side of the embankment; and where the diameter of these pipes is too small to carry off all the water, there should be two or more of them laid across under the track parallel with each other. By laying the pipes with a fall of about 1 foot in 10, or even more, their carrying capacity is increased and the danger of becoming choked with sand or debris diminished.

Where the conditions are favorable and the cost is not too great, stone arched openings should be put under the track, with good, strong, side walls, a paved floor and deflecting wings at both sides of the embankment; these to take the place, as far as possible, of all small wooden bridges.

CULVERTS AND BRIDGES.

8. The policy of most railroads in regard to bridges and water ways is to contract the limits of bridges and trestles as much as is practicable, because earth is a much cheaper article to support the track where it can be used with safety. This is also the reason why box culverts are substituted for small bridges wherever it can be done, and at many places where it should not

be done, as, for instance, at points where the opening is not large enough to carry off the amount of water which must pass through under the track. Then the culvert generally washes out, the earth above it is undermined, and the result is a wreck of more or less magnitude, unless the trackmen discover and repair the damage in time.

Even when wooden culverts are covered with earth, parts of the side timbers project on the ends, and there is always more or less rubbish, dead grass or weeds, which accumulates at the mouths of them, making the liability to accident by fire almost as great as on trestles or bridges.

When nothing but wood is used in the construction of bridges or culverts, small pile bridges should be used instead of box culverts. There is less danger of the bridges washing out, while liability to accident by fire is about the same, and a man patrolling the track can see at a glance when an open bridge is safe, while he must often go 20 to 30 feet below the track to examine a culvert.

GRADING CUTS.

9. Wet, soft cuts on railroads are a great annoyance, and very expensive for the companies that are troubled with them. They are the chief cause for increasing the section force and for which ditching gangs and extra quantities of ballast must be furnished.

In the spring and summer the track in wet cuts is rough and sometimes hard to find where there is no ballast under it. Trains must run slow and the wear and tear on rolling stock is greater than at other points on the road. In the winter the track in bad cuts is heaved up, and it requires considerable extra labor and expense to keep it passable, and owing to the frequent

spiking and the nature of the material in which they are laid the ties soon rot and have to be renewed. For new railroad construction there is a cheap and effective remedy for the evils above mentioned which is seldom or never adopted. This consists in widening the roadbed in proportion to the height of the cut, or in conformity with the nature of the material through which the cut is made, instead of following out the ironclad rule which makes the width of the roadbed the same in all cuts, whether in rock or yellow clay. A practical and experienced man should have full charge of the grading work on a new road, and he should be at liberty to widen the roadbed, or ease the side slopes of any cut, in a manner which would protect the track from the effects of heavy rains or a springy bottom.

Surface ditches should be put along the tops of all cuts to run off the water at the ends, and to prevent it coming in on the track over the faces of the cuts.

CHAPTER V.—SUMMER TRACK WORK.

RENEWAL OF TIES.

1. The month of May is the season when the work of general track repair should be pushed steadily. Track is becoming dry in many places, and heaved track is settling back to its old bed.

Section foremen should select parts of the track at the furthest ends of their sections, and work in the following manner. Tamp up all low places to the proper surface and level; tighten up all bolts; put a good line on the track, and take all kinks out of the gage side; fill in the center of the track where necessary, and dress it out of a face, cleaning the shoulder of all weeds, and strengthening the embankment at all weak points as you go along. In fact, do everything necessary to make a good safe track. Do not slight anything, and you will have the satisfaction of knowing that so much track as has received your attention is in good shape, when you are called away to do other important work, such as putting in ties, cutting weeds, laying new steel, etc. Add to this good track daily, and save making so many excursions after that particular low joint, bad bridge approach, or battered rail, all of which jobs if looked after separately, consume lots of valuable time. Every section on a mud road ought to have a mile or more of ballasted track so that time which would be lost in spring or rainy weather could be spent on this portion of the track to

advantage. It is a common sight to see a section gang tinkering around switches or slopping around in a muddy ditch while waiting for the ballast to dry. As a large proportion of the time so spent is wasted but must be paid for just the same, it follows that the ballast given to a section is doubly economical, effecting, as it does, an improvement in track, and also a saving of money that would otherwise be spent unprofitably.

When the time comes for putting in new ties, those broken under the track rails, or where there are several rotten ties together should be removed first. The work of changing ties should be well done. Ties should be properly spaced, laid square across the track, and tamped solid up under the rail. The number should be increased wherever there was a wide space between the old ties. If, when putting in ties near a joint, a shoulder tie is found too weak to hold a slot spike or a joint tie is not large enough to give the required support and yet sound enough to last a year or two, it is best to move them to one side, when a rotten tie has been taken out, and put in a new tie. Joint ties especially should be changed whenever they show signs of weakness. The best time to do this is when surfacing track, because the dirt between the ties has been used in tamping and the ties may be moved without much labor. Still it will pay to do it even when simply renewing ties.

Track should not be ballasted or surfaced out of a face before frost is entirely out of the ground, nor should new steel be laid until the track is in a good condition to receive it except when a gang of men is furnished to go along and fix the track as fast as it is laid. But such work is better if delayed until the weather is warm and the ground thoroughly dry.

By the first of June, section foremen should have

their track in as good a condition as possible, so as to give most of their time to cutting weeds and surfacing, without having to do so much general repair work.

TRACK TIES

2. In ties or sleepers, the species of the wood entering the same are of great variety. They range from cedar and other soft woods to lignumvitae. The majority are, however, of cedar, cypress, hemlock, pine, chestnut and oak, and are used according to the portion of the country the railroad runs through. In size they vary according to the specifications of the particular company that they are being cut for. The lengths run from 8 to 9 feet; thickness, 6 to 7 inches; and the face, when hewn, 6 to 9 inches. Timber cross-ties can be divided into two general classes, and these in turn can be subdivided as follows:

1st. Hewn.

- (a) Quarter tie.
- (b) Slab tie.
- (c) Half tie.
- (d) Uneven tie.
- (e) Pole tie.

2d. Sawed.

- (a) Quarter tie.
- (b) Slab tie.
- (c) Half tie.
- (d) Pole tie.

Fig. 12 shows, at upper part, first, a quarter tie; that is, a tree quartered into four ties, that has very little heart, as one corner of same, which, if placed in track with heart up, will check quickly; and if put with heart down, as shown below same, and the spikes are driven in, will split the heart part away from the rest of the tie. A slab tie is shown at No. 2; that is, a

tree halved into two ties, and the same results occur as from quarter ties. At No. 3 a half tie, which explains itself. These ties, when the heart is placed down, give for support of the rail only sapwood, which will be quickly cut into. At No. 4 is shown an uneven hewn tie with a face of 3 inches on one side, which, if placed up, will very soon be cut into by the rail base, as shown below same. Nos. 5 and 6 show pole ties, so-called, which are the best for use in track, owing to the heart

RAILROAD TIES.

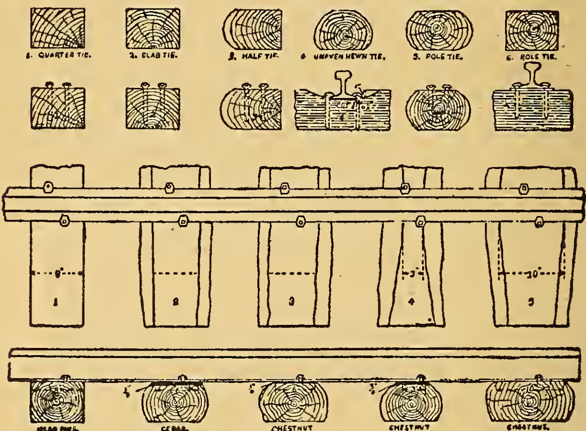


FIG. 12.

being at the center, with sapwood on the outer corners only; and such ties, when placed on track, will give longer life and allow correct spiking for gage and to prevent creeping, and will not require so quickly the use of plates on tangents; whereas the other ties when used should have a tie plate with some, if sap is placed up, to prevent their being cut into.

On lower part of cut is shown, first, a hard pine tie, then a cedar, then a chestnut, then a narrow-face chestnut and a wide face chestnut tie. It will be no-

ticed the hard pine tie is cut in but little, the cedar and narrow-face chestnut the most, which would occasion, if ties thus placed were of different wood or of different face, an uneven bearing for the rail base when the wheels are upon same.

There can be brought up also the objection of narrow and wide face ties placed near each other, especially if under a bridge or at a highway crossing, owing to the fact that frost will hang under wide-face ties and come out quickly under a narow-face, making uneven riding track in the spring. Above same on cut is shown a rail spiked to such ties with the face shown. In the tamping of track, a pole tie as shown at No. 5 can be worked more quickly to a good bed than any other, and if half ties are used, as shown at No. 3, the tendency is for them to cant, unless trackmen are careful in the tamping of same. Where square ties are used, except in rock ballast, more labor is required to tamp them to a good bed than of pole ties at No. 5 style. For economy of material, it is to advantage, then, to make use of ties of the same kind of timber together, and not mix the hard and soft woods, to give good riding track. Also, the same reason holds good to prevent the tearing up of the track in frequent renewals of ties, where the different kinds of wood are used promiscuously, as a cedar tie of good heart will last twice as long as any other tie in the ground. Chestnut comes next, then hard pine; though it is admitted that white oak ties should rank to cedar, provided you get them of good timber. All other kinds of oak or hemlock it is not advisable to use, owing to their short life of only about four years, demanding frequent renewal, which is not economy of labor, as well as damage to the rail upon same.

It is not always possible to procure the best ties,

but an effort should be made to have them above the average, even at an increased price. Other things being equal, a railroad which is not compelled to renew its track ties for nine or ten years after they are laid in the ground, has an immense advantage over a road that must renew its ties once in five years. The latter road must figure into its expense account almost double the cost for material, besides the additional track labor necessary to do the work, and during the interval it cannot have as good a track as the former. Ties sawed square will rot quicker and break easier than hewed ties, and are generally too small to give a good bearing surface. But pole ties, with a face on two sides, made by sawing slabs from them, are generally good and preferable to quarter ties or ties split out of very large logs, because the wood of a big tree is more brittle than that of a younger growth. A well hewed pole tie, with a face on two sides, eight to ten inches wide, is preferable to all others for track purposes. No tie should exceed seven inches in thickness, and all ties should be cut a uniform length for main track, except in bridges and switches. It seems to be a very difficult matter when constructing a new railroad, or when procuring new ties for renewals, to secure ties of a size that will be uniform in width of face and thickness. In regard to the length of ties, the ugly and irregular line of ties on the gage side of track, caused by the difference in the length of ties, is the result of gross carelessness in the office or company that accepts them from the tie maker. If ties were all of a uniform length, besides improving the track, it would prevent uneven settling of track; and by lining evenly on both sides, they aid the track foreman in arranging the ballast a uniform width on each side of track, and prevent the useless work spent in tamping

the long ends and digging out for them, and on mud track it would lessen the labor of weed cutting. The life of a track tie is not altogether dependent upon the kind or quality of timber used.

The same kind of a tie will last longer at the North where the ground is frozen all winter, than in the South, where the process of decay goes on uninterruptedly. There is also a marked difference in the effect on ties of an extremely wet or dry climate, or the amount of traffic over them. If the length of ties equaled twice the gage of track, they would give much more support to the rail and center bound track would not be heard of. As it is, the ties receive their main support from the inside and only a small proportion from the outside ends. This condition soon develops swings and rough track. If the rail received as much support from the outside as from the inside the ends of the ties would not spring up and down under a passing train; consequently there would be no space between the ends of the ties and the ballast beneath for water to get into and the tie would rest solidly on the foundation from end to end. This would have a material influence in holding the track in line. The increased cost of longer ties would be more than offset in the saving effected in the expense of keeping track in repair and there is reason to believe that the life of the tie would be increased also.

RENEWING TIES.

3. When putting ties under the track the foreman should never allow the men to dig out any more than is necessary to allow the tie to go under easily. The old bed should not be disturbed if the new tie will fit. A very good method for putting ties in a mud track, where there are a good many ties to be changed, is to dig out between every two rotten ties, and on each

side of the track, a little deeper than the bed of the ties, pull the spikes from the old ties, spring the rail on a tie either side of the hole which has been dug, and slip a spike under the rail. Use nothing thicker than a spike. Then knock the old ties into the hole, and pull out. Pull the new tie into the same hole from the opposite side of the track, if it is of about the right size; let a man on each side of the track slide the tie into its bed, keeping it close up to the rail until in its place. If the place to receive the tie is a little too deep, scatter a shovel or two of fine dirt evenly over the bed, then slide the tie under the rail as before. When both new ties are in, take the spike from under the rail, and you will find both ties in better shape than if tamped under for several minutes. The ties will hug the rail and very seldom be over an eighth of an inch too high, an error which cannot be seen after the first train passes over.

The above method is the best, safest, and quickest for mud track. When ties are put in this way there is no tamping to be done, and they can be spiked without the necessity of having a man to hold up the ends of the ties for the spiker. In gravel or stone, the ties must be tamped, and should be held up to the rail when spiking them.

When men have had some practice at putting in ties in this way, they can put in one-third more in a day, per man, than by tamping; and in much better shape. But it is not advisable to raise the track up to put in ties in gravel, because the gravel will run under the ties and spoil the surface.

New ties should always be spaced evenly; they should be square across the track, and on single track laid so that the same length of tie will project outside of each rail, as very short or long ties, if put to line on

the line side, would give an uneven bearing surface for the rails, thereby making track difficult to keep level. The only necessity for a line side on such ties is when laying new track. But on double track the outside of each should be the line side.

SELECT YOUR JOINT TIES.

4. Under joints where angle bar splices are used, put in two well-hewn ties of about equal size, and have each tie come well under the angle bar splices not over six inches apart. When putting in ties a foreman should divide his gang in such a way that all can be working at once, having each man do the work he is best suited to perform, and when working a large number of men he ought to have tools enough to work them in separate gangs, because in this way a great deal more work can be done in proportion to the number of men. Ties sawed square should never be put under a rail joint.

FINISH AS YOU GO.

5. When a section foreman is putting in ties out of a face, leaving the track level well tied behind him, he should take time each day to level up all low places in the piece of track laid, dressing it up, not only in spots where the ties have been put under, but continuously. He should, if necessary, cut the weeds at the same time, and do any other work that is needed. By doing the work this way he leaves behind him every day a good piece of track, which grows longer as he advances, and shows up to his own advantage, and his superior's satisfaction.

DISTRIBUTING NEW TIES.

6. When new ties are being distributed on his section, a foreman should be particular to so distribute them that it will not afterwards be necessary to haul

them any great distance to where they are wanted. Hauling ties half a mile or more with a push car to where you want them, when they could as well have been put there with the train, is only a waste of time and labor.

MAKE THE WORST PLACES SAFE FIRST.

7. When the number of rotten ties on a section is very great, or when the bad ties are in bunches, from three to ten together in a rail length, making the track unsafe, always look to such places first, and get in enough new ties in these places to make them safe, and keep track in good gage. After you have done this, then will be time enough to commence putting in the new ties out of a face.

When putting in new ties out of a face, if the old ties left in the track are not to gage, bring to the proper gage with new ones; don't leave them an irregular gage.

TIES UNDER JOINTS.

8. When supported joints are used and two on opposite sides of the track are not squarely opposite each other, never try to twist one tie around so as to make each end of it come under the center of a joint. This makes the joint weaker than any other part of the rail in proportion to the difference between the square joints. When rail joints pass each other so much that the center of each joint will not rest on opposite edges of a good tie, put into track another tie, so that the center of each joint will rest on the center of the large end of either of the ties. Track is much better and easier to keep up to surface where there are plenty of ties under it. A good method for spacing ties is to have the space between all ties just wide enough to pass a track shovel up between them. Where cedar

ties are used there should be not less than seventeen to a thirty foot rail length. This, however, depends on the weight of rail and conditions of traffic, and is generally regulated by special instructions.

ESTIMATING NEW TIES FOR REPAIRS.

9. In the fall of the year, or at any other time that section foremen are requested to send their roadmasters an estimate of the number of new ties wanted for repair of track on their sections, the foreman should make a personal examination of every tie in the track in his charge, working with an adze and counting every rotten or broken tie which must be removed from track before the end of another year. In the statement should also be included the number of ties wanted to repair his side tracks, and any extra ties wanted to fill wide spaces, which may have been omitted when the track was first laid. If a record is kept of such estimates the foreman will find it convenient to refer to later on when distributing ties, as he will then know exactly how many are needed at each place on his section.

COUNTING THE BAD TIES.

10. When the bad ties are counted, each one should be examined, and tried with a pick, if necessary. Do not run over the track on a hand car, carelessly counting the ties as you go, nor make an estimate of the number of ties wanted by guess. The number of ties wanted each year for repairs is an important item of expense to a railroad company, and all estimates for new ties should be made as accurate as possible.

WIDE SPACES.

11. When putting in new ties track foremen should see that all wide spaces are filled between the old ties which were too far apart when the track was laid, or

where other foremen neglected to space them properly, putting in two for one, or three for two wherever necessary.

REMOVE BAD TIES WHEN BALLASTING.

12. When a track is being ballasted with gravel, stone or other material, all the bad ties should be replaced by new ones as fast as the track is ballasted. The work of changing ties is more easily done when ballasting, and costs less; and the track does not have to be disturbed again for a much longer period. Although it is contrary to general practice, it is held by some authorities on track work that when surfacing track it would be cheaper in the end to remove all ties that will not last two years instead of one year only. If this was done a piece of track put in good shape this year would not have to be rooted up again next year. If a foreman must go over every rail in his section each year in order to renew ties he will have little chance of getting ahead of his work.

TWISTED TIES.

13. Foremen putting new ties into the track should adze off the edge at the ends of all twisted ties, sufficiently to give the base of the track rails a level surface to rest on for the full width of the tie, at each end of it.

TIES AT HIGHWAY CROSSINGS.

14. When new ties have been distributed along the track, the section foreman should go over his section immediately after the distributing train, and remove to a safe distance all ties which are too close to the track rails, or in a dangerous position. All ties on the ground close to highway or farm crossings should either be put into the track at once, or removed to some place where there would be less danger of their being

stolen, or obstructing the highway. All ties should be in square piles of about seventy-five each. Section foremen should not overlook any crossings when putting in ties; the plank should be taken up, the track examined, and all the new ties needed put in there.

REMOVE THE BARK.

15. The bark should be removed from all hewed or round timber used in railroad construction, before it is put into service in the ground, or above the ground.

Bridge piles will remain sound much longer, if the bark is removed, and they are allowed to season, before they are put in the ground, because the water which falls on the wood above the surface of the ground, soon evaporates, and leaves the timber in a good, dry condition. If the bark is allowed to remain, it prevents evaporation of the sap, or other moisture, for a much longer time, and therefore induces decay. The same may be said of fence posts, and there is considerable loss occasioned by nails or other fastenings not securing a firm hold on the wood, where they are driven through the bark.

In the case of track ties, the bark, if not removed, assists materially the process of decay, and it is also a continual source of annoyance to the track men when tamping or repairing the track, and dangerous on account of fire. The best time to remove the bark from ties is during the winter months, before the ties are distributed along the track. A number of roads are using preservatives, or "pickling" their ties, to increase their life. It certainly pays to do so, not only on account of the increased life of the tie, but principally because it effects a great saving annually in the cost of removing ties, and thus removes the necessity of digging up track that may be in good line and surface,

simply to take out the rotten ties. The life of ties has been doubled and tripled, showing an immense saving in the cost of tie renewals.

OLD TIES.

16. The best way to dispose of the old ties, which are taken out of the track, is to get rid of them with as little expense and handling as possible. After the section men receive what old ties they require for firewood, the balance should be traded for work, or given away to people living along the road, with the understanding that the old ties be removed at once, after they are taken from the track.

There is a large amount of labor wasted in picking up, hauling, piling up and burning old ties which had better be devoted to improving the track. In most sections of the country where timber is scarce, the farmers living along the track will do plowing or grading, or give labor on the track equivalent to the value of old ties.

AVERAGE LIFE OF TIES.

17. The average life of ties can only be determined in localities where they are used. Ties made from the same timber will rot quicker in one kind of soil or ballast than they will in another. The climate also affects the life of a tie, as also does the amount of traffic over the road, the width of rail base, etc.

Another point to consider, when calculating the life of a tie, is the condition in which it is allowed to remain in track. Some companies have all the old ties removed from track as soon as they will not hold a spike, while other roads allow old ties to remain in track until they are entirely worthless. The latter roads gain another year's use of the ties, but it does not pay except in the case of an occasional tie, broken or rotten

in the center, but still giving the rails a good support at the ends. Any tie which has begun to give away under the rail should at once be replaced by a new one. When bad ties are numerous it is impossible for trackmen to repair the road without putting under new ties.

18. TIE ACCOUNT FOR A YEAR.

MONTHS.	TIES RECEIVED.		PUT IN TRACK.		ON HAND.	
	HardTies	Soft Ties	HardTies	Soft Ties.	HardTies	Soft Ties.
January	1000	500	none	none	1000	500
February	none	100	none	none	1000	600
March	300	none	1100	200	200	400
April						
May						
June						
July						
August						
September						
October						
November						
December						

Track foremen will find the above form a handy way to keep a correct account of ties handled on their seection. If it is necessary to keep account of more than two kinds of ties, additional columns may be put in under the three heads, "Ties Received," "Put in Track," or "On Hand." However, most roads furnish blank forms for this purpose.

CHAPTER VI.—CUTTING WEEDS.

POINTS ABOUT WEEDING.

1. Weeds on track should be cut clean with the shovel between the ties and out to a distance of at least 2½ feet, when making first cutting and cut to bank line on fills and to ditch line in cuts at last cutting. When cutting weeds the ends of ties should be watched closely and any dirt that will interfere with their drainage removed. On embankments, the weeds at a greater distance from the ends of ties than that mentioned above should be kept cut down with a scythe or brush hook, as far out as the right of way limits, if the foreman is allowed men enough to perform this work without neglecting the track or other necessary work. A clean track is not by any means a safe track, and a foreman should not have his men mowing grass and weeds along the right of way, unless the help he is allowed and the condition of his track at the time will admit of it. Before commencing to cut weeds a foreman should grind on the inside of the blade any new shovels he is about to use and bevel them back from the edge about five-sixteenths of an inch. He should also carry a flat file to use when necessary, and never allow his men to hammer shovels on the edge of the blade, as this practice causes pieces to break out of the front of shovels and render them almost useless. A foreman should watch his men when cutting weeds and see that the weeds are cut under the surface of the ground, as those which are only taken off above the ground commence growing immediately after being

cut. When weeds are cut in the center of a track or on an embankment, the dirt which comes on the shovel together with the weeds should not be thrown down the embankment, but be either turned over or allowed to remain where it was moved from. The practice of shaving off the embankment one or two inches every time weeds are cut is bad, and should not be tolerated, as the loose dirt thrown down the hill soon washes away, and each additional weed cutting of this kind weakens the shoulder, makes the fill narrower, and in time allows the ends of ties to project over and track to settle for want of a sufficient foundation.

When cutting weeds, always have your men cut on separate rail lengths, as this relieves the monotony of the work; it also acts as a stimulus, making each one anxious to do his part of the work in time to take his place in turn with the other men.

WEEDS ON HEAVY GRADES.

2. If a section foreman's help is so limited that it is not possible for him to keep all of the track in his charge clear of grass and weeds during the summer months, he should commence part way up the heaviest grades on his section, and cut the weeds clean out of the track to the top of the grade and down the same distance on the opposite side. This will enable heavy trains to go through without any inconvenience, and the weeds in the sags can be cleaned out afterwards as the foreman has the time to do it.

If the section is all level track you can follow the same plan, cutting the weeds a quarter of a mile or more in one place, occasionally skipping a piece. This will enable an engine to gain speed enough where the track is clear, to haul the train without slipping, over places where the weeds are not cut.

TO LESSEN WEED CUTTING.

3. The labor of weed cutting on a dirt-ballasted track may be lessened a great deal by work done on the section in the spring before the weeds become troublesome, by the following method: At all points where a foreman puts a number of new ties in the track near together, he should stop long enough to surface up the track, line and dress it out of a face, and by this means kill the young weeds, or at least retard their growth at that place. After a foreman is well advanced with the work of putting in ties, some of the old ties may be traded to farmers living near the track for plowing a couple of furrows along on each side of the track ten or fifteen feet from the rail, and in a line parallel with the track, keeping a little outside the bottom of the track embankment. Have this work done where it is high and narrow, especially where the shoulder of the track outside the ties has been weakened by surface washing or from constant weed cutting in previous years.

After the plowing has been done the foreman should take his men and level up all low spots in the track and line it up ready to fill in and dress. Then put part of the men to work on each side of the track and have them cut the plowed sod into handy lengths and lay them along at the ends of the track ties with the grass side down, and fill the balance of the track in the center and between the ties with material taken from the bottom of the newly plowed furrows and dress and finish the track with it. This work should be continued as long as you can spare the time from other necessary track work and by the time regular weed cutting begins you will have one or two miles of first-class mud-track with all the old grass or weeds

killed. The track will be strengthened and kept in better line, and, there being no weeds in the material taken from the plow furrows for ballasting, you will be saved the necessity of cutting much weeds on that piece of track all summer, and all your other work will be advanced proportionately.

In connection with this subject attention may be called to the fact that quite recently extensive experiments have been made on some of the prominent roads

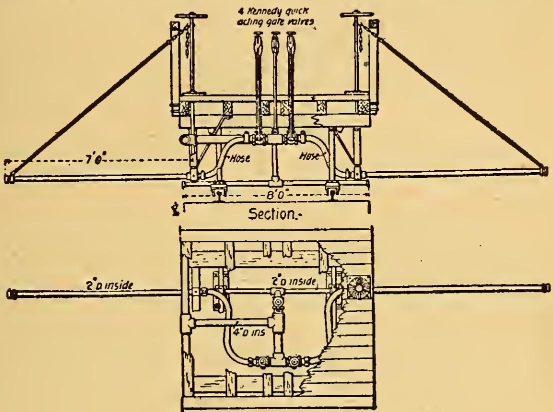


FIG. 13.

sprinkling roadbed with oil, for the purpose of preventing excessive dust raised by fast trains. The observed effects have been very gratifying. Not only does the oil prevent the former clouds of dust, but it has proven useful in other ways; the oil acts as a tie-preserving agent, prevents the water from soaking into the roadbed, and finally discourages the rapid growth of grass and weeds. The oil is applied on cinder, sand, gravel, or earth-ballast, with equally good results, and many Western roads are now making extensive tests for both destroying the weeds and grass,

also to prevent the heaving of track by frosts. Any evolution which will relieve the track department of weed cutting and at the same time allay the dust will soon meet with general approval.

We show herewith in Fig. 13 a section and a plan of the Q. & C. oil sprinkling car. A 4-inch pipe runs the full length of car with rubber hose attachments to oil supply, which is carried in ordinary tank cars; to this main pipe other pipes are attached by rubber hose so that they can be raised or lowered according to the surface of roadbed. Each side sprinkler is adjusted by a hand wheel with chain attached to vertical staff supporting outer end of pipe. The rails are protected from the oil by a suitable device, as shown in sectional view.

TOOLS FOR WEED CUTTING.

4. Although a shovel is the tool most commonly used for cutting weeds on railroads, tools, such as are shown in Figs. 14 and 15, are now being gradually substituted on many roads on account of their superiority in many respects. In the first place, they are more convenient for the men to use, are not so tiresome, and can be handled with greater ease, the men standing in an upright position, when cutting weeds with them, instead of a stooped or bending over position, which must be assumed with a short-handled shovel. From one-sixth to one-fourth more weeds may be cut in a day with this tool than can be done with a shovel. They are less expensive than shovels, and are therefore more economical to use, and the dirt or ballast which would be lifted by a shovel and wasted by careless men is not disturbed by the tools shown, when weeds are cut, but remains in its original position in the center of track or on the shoulder of embankment.

This last advantage alone is a sufficient reason for their general introduction on all roads in preference to shovels.

The weed cutting tool, shown in Figures 14 and 15, should have a blade made of very thin, hard steel. The

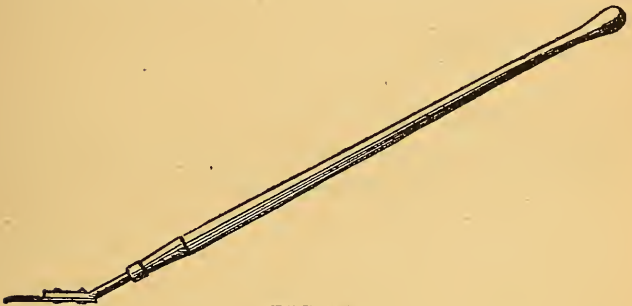


FIG. 14.

blade of the hoe, as manufactured for garden use, when properly tempered, is the correct thing, because, although the edge gradually wears away, yet it never requires sharpening, as thicker blades would on account of coming in contact with stone and gravel.

Section foremen can improve the appearance of their track greatly and save considerable labor by bolt-

FIG. 15.

ing a piece of timber to the end of the hand car, projecting far enough out on the side of track to attach an iron rod with a small steel shovel at the end of it, which will mark the outside line for cutting weeds as the car is pushed ahead on the track. A still better way is to attach a thin steel wheel, which offers less resistance to the motion of the car.

CHAPTER VII.—BALLASTING.

BALLAST.

1. If stone is difficult to obtain, a good track can be made with gravel and stone combined for ballast, than when either of these materials is used alone. The foundation for the track should be laid with broken stone, and above the stone should be placed a quantity of coarse gravel sufficient to bed the ties, surface the track, and dress it. Where gravel and stone are used together, as above stated, the stone need not be broken as small or uniform in size as where stone is used alone for ballast. Gravel and stone when used for track ballast have, each, advantages peculiar to themselves. Stone makes the most solid foundation, drains the track best, does not freeze in cold weather, does not grow weeds, will not wash, and makes very little dust. On the other hand, gravel is easier to procure along most roads, costs less than stone, is more elastic, not so wearing on track ties and rails, or the rolling stock as much as stone, drains the track well and does not grow many weeds. It also possesses superiod advantages in handling, little more than half as much labor being required to surface a given amount of track as when stone ballast is used; and all kinds of track repairs, especially changing ties, can be made much quicker and cheaper in gravel than in stone ballast. Two car loads of gravel to a thirty-foot rail length, laid upon a layer of broken stone twelve inches thick, will

make a first-class roadbed, but the proportions of gravel or stone used for ballast should depend on the kind of bottom over which the track was laid, the cost of materials and the amount which could be furnished.

Cinders will be found equally effective as a ballast, except in very wet cuts, where stone should be used, and are cheaper than either stone or gravel, inasmuch as the cost of loading is an expense that cannot be avoided. Six inches of cinders will absorb about one inch of rainfall, and for this reason will keep the foundation beneath the ballast dry. They are superior to any other ballast on clay fills or gumbo bottoms, and are sure death to weeds.

SURFACE LEVELS.

2. When it is intended to ballast several miles of old railroad, or when ballasting track out of a face behind tracklayers, levels should be given by the engineers just as for bedding ties, with only this difference, that the top of the level stakes should be the surface level of the track rails. These level stakes could be arranged so as to answer for lining track, like center stakes, and in all cases where track is newly ballasted, provision should be made for putting it in perfect line, more especially curve track which should be lined as originally located.

BEFORE BALLASTING TRACK.

3. All track that is about to be ballasted with cinders, gravel or stone should be cleaned out to a level with the bottom of the ties, and the dirt taken out should be put along the shoulder of the grade, to strengthen it and save the ballast from washing away. Deep sags should always be raised up the required height before track is ballasted. It is a bad policy and a waste of material to increase the depth of ballast in

order to level up a deep sag in the grade. If the dirt between the ties in a new track is not taken out before putting under ballast of cinders or gravel, it soon mixes with the ballast used, and works gradually to the top in wet or low places, making the labor of repair more difficult, and growing more weeds. Where the ballast is of sufficient thickness, or in taking up sags, or where it is intended to ballast one-half mile or more, the digging out can be omitted, provided there be no particular reason to keep the track down to a certain grade. Digging out track is very expensive, and should not be done except on top of grades, in clay cuts, or any point where it is intended to ballast only a short stretch of track. The grade on high embankments before receiving ballast of gravel or cinders, should be made at least fourteen feet wide, and as much wider as is possible without too great an expense.

WHEN TO BALLAST.

4. On Northern railroads, track should not be ballasted earlier than May 15th or June 1st. The ground should have time to settle, and the heaving to go down.

BALLASTING.

5. When a foreman is putting ballast under the track he should raise the track out of a face, taking out all light sags where there is enough material to do it.

RAISING TRACK.

6. The following is one of the best methods of raising track to a level surface:

Take a piece of board two inches by four inches, and five feet long, place it across the track, and cut notches in it three inches deep, near the ends, so that it will fit between the track rails like a gauge. Put this board on a high place in the track about ten or twelve rail lengths ahead of where you will commence to raise

the track, shim it up at the end to a perfect level, at whatever height will be the top surface level of the track rails after they are raised at that place; you may then go back and begin surfacing. Test with board before tamping inside rails.

When sighting track, have each joint raised and tamped one-fourth of an inch higher than the top of the sighting board, and on reaching the last joint, raise and bring it to a level with the finished track by striking down on the tie once or twice with a sledge, or other heavy tool. The center of the rail should only be raised to a level with the joints.

The man sighting track should sit at least sixty feet back of the joint which is being raised, and ninety feet back is better, because the long surface of rails raised assists the eye to more accurately sight a true and level line ahead. When trackmen sight at the first joint back of the one which is raising, light sags are apt to get into the surface of the track unnoticed, as swings do when men stand too close to a place in track when they are lining.

Use two jacks when surfacing with a large gang of men, a heavy jack for the joints, and a lighter one for lifting the centers of the rails. Do not allow the jack men to lift up rail centers high enough to spring the rails, and always have the jack set in ahead of the joint next to be raised, except when the rail is surface bent in the quarter behind the joint. Tamp up the tie ahead of the joint with the joint tie when raising track more than two inches. This prevents the joints from hooking over and making it necessary to go back and raise them a second time.

Always sight curve-track along the inside of the rails. In that way you can see further and better.

When making a "run-off" for trains be sure to have it long enough to let them over it easily. Time can be saved by only tamping three ties solid ahead of the last joint raised. The material can be thrown loosely under the balance of the "run-off" and the track let down upon it.

Have your men well organized, each one working in his proper place, and if you employ new men pair them with older hands. If you have a gang of fourteen or sixteen men work them as follows: Put two men tamping out ends of ties on each side of the track, four men tamping the centers of ties inside the rails, and two men with the jack. The balance of the gang may be divided, a part of them filling in the ballast ahead of the men tamping and the others filling in behind the men tamping. If you work your men so that they will be about evenly divided on each side of the track they will be more apt to compete with each other and help forward the work. You can see at a glance whether each one performs his share of the work or not and you will also be prepared to finish up a piece of track quicker, when necessary, than if the men are allowed to straggle along and work where they please.

For inexperienced men it is a good method to sight track over the tops of two small blocks which are of an equal height with the sighting board or a painted line upon it. The man with the track-jack carries one block, and when the top of this block is placed on a rail joint and comes up level with the sight-board and the top of the track-sighter's block, the joint is high enough. These blocks are not used when sighting the center of the track-rail.

RAISE BOTH SIDES.

7. It is best to raise both sides at once when bal-

lasting, as track raised and tamped on one side before it is on the other always has a space not tamped under the rail, on the first side, when the opposite side is brought up to level. The center of ballasted track should never be tamped solid; it will be enough to fill under the center of the ties without tamping very solid. About eighteen inches inside the rails on each side of the track will be enough of the inside of the ties to tamp solid. It should be remembered, however, that it is a rare thing to find two men who use the same method of raising track. One would be surprised at the wide difference in the proceedings of foremen while raising track. One from long practice will be skilled in his particular plan and seem to make excellent progress, but if ordered to raise track according to some other method he may make no headway whatever. As it seems to be a matter of experience or judgment, each foreman should be permitted to follow his own ideas, so long as the results attained prove satisfactory.

SOLID CENTERS.

8. Where the weight of the engine and the cars bears most on the center of the ties, great numbers of them break, especially ties sawed square, hence the necessity of using ties 9 ft. 6 in. long. On Northern roads, when the frost is leaving the ground in the spring, the ends of ties thaw out first, and where they are very solid in the center they rock under the weight of a train and the track slides out of line.

HIGH PLACES.

9. Short high points in the track to be ballasted should not be raised at all if they are higher than the surfaced track, but should be let down, if this requires less labor than to surface up the track to the high point.

UNIFORM TAMPING.

10. The secret of putting up good smooth track that will remain so a long time, lies in having your men well organized and in getting them to work as nearly alike as possible; uniformity in the work is everything. A first-class track can be ballasted without tamping it with either tamping pick, bar or shovel handle, where sand or gravel is used, by having the men put the material to place under all the ties with the shovel blade, tamping only the joint ties, and picking up the low places after some trains have passed over it.

A question which is frequently asked is, "Should the tie be tamped throughout its entire length?" In answering this in true Yankee fashion, it can be said: "Does a man, in building a house, only support it at the four corners?" Unquestionably a tie should be tamped throughout, so as to furnish as solid a bearing as possible for the rail; but care should be taken that it does not "become centerbound," or, in other words, the middle of the tie so supported as to cause the track to rock. On double track roads it will assist the general condition of the track to tamp the leaving side of the tie the harder and the last, thus forming a wedge and arresting any slight forward movement.

Although more expensive in the first cost, stone, if rightly selected, will give the best results and be the most economical ballast to maintain. In addition, it is appreciated by the traveling public, owing to the absence of dirt and dust.

DRESSING BALLASTED TRACK.

11. If soil or loam is used it should be filled in the center about three inches in depth and slope down and outward, so as to leave about two inches of open space

under the rail and then carried out so that the ends of the ties will be at least one inch above the dirt in order to provide necessary drawings. If the ballast used is coarse gravel, or cinders, and there is sufficient ballast under the track to drain it well, it is the best when dressing the track, to fill up between the outer ends of the ties with ballast, leaving it level with the top of the

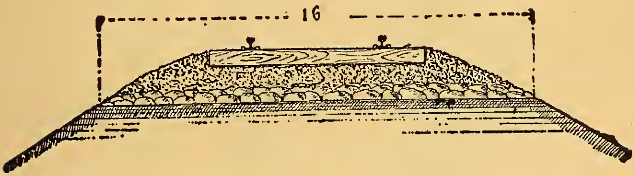


FIG. 16.

ties and then putting a good heavy shoulder of the ballast outside the ends of the ties, dividing the material evenly on each side of the track. The shoulder of track should be of a regular width. Where there is a surplus, put it at weak places. This, however, is generally regulated by the Standard Sections of Roadbed, which are getting adopted more and more by the different railway companies; in Fig. 16 is shown a diagram of roadbed section ballasted with gravel and

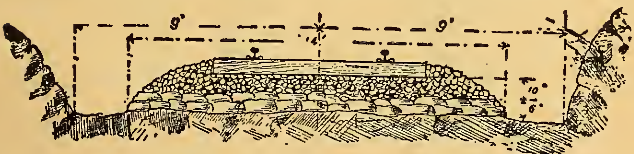
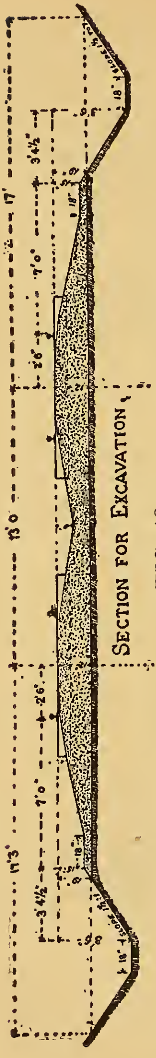


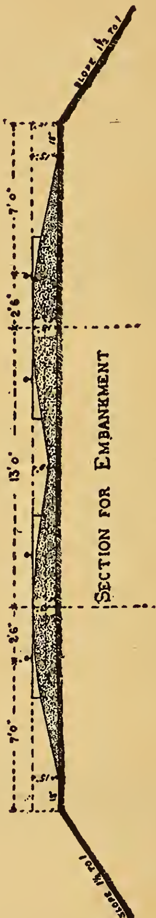
FIG. 17.

broken stone; Fig. 17 shows roadbed section for single track in a rock cut, while Figs. 18 and 19 show standard double-track sections for gravel ballast on the L. S. & M. S. Ry., and Figs. 20 and 21 standard sections



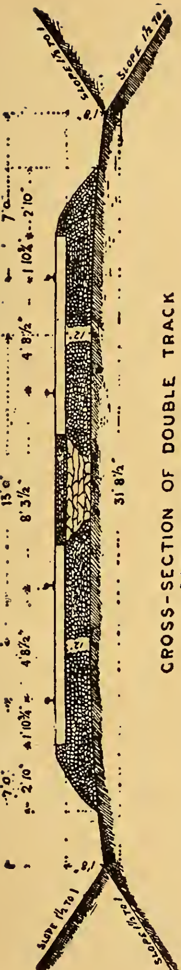
SECTION FOR EXCAVATION

FIG. 18



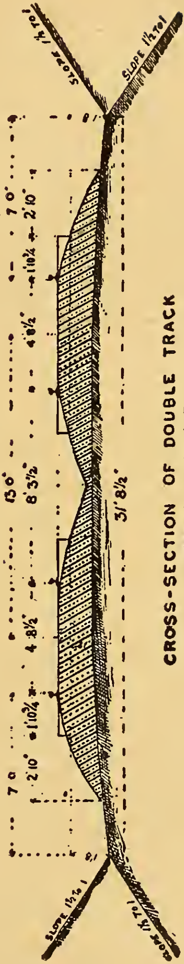
SECTION FOR EMBANKMENT

FIG. 19.



CROSS-SECTION OF DOUBLE TRACK
BROKEN STONE BALLAST

FIG. 20.



CROSS-SECTION OF DOUBLE TRACK
GRAVEL BALLAST

FIG. 21.

for ballasting with gravel or stone on the N. Y., L. E. & W. R. R.

A DAY'S WORK.

12. Sixty feet, or two rail lengths, of finished track ballasted per man, per day, is generally considered fair work for a surfacing crew. If possible, a foreman should finish up, before leaving for home, all the track raised during the day, as a heavy shower of rain, or a storm of snow and sleet will injure any track which is left open and not filled in the center between the ties.

A little judgment will enable any foreman to so arrange the work that, when himself and his men get through work in the evening, the track where they were working will be in good shape, and safe, if they were not to return again for several days. It is very important that all track should be filled in and dressed up as fast as it is surfaced, in order to preserve a good line on the rails. Track which is not filled between the ties will not stay in line. No material should be piled upon or around the track which would in any way stop the free passage of water which falls on the track.

REFUSE BALLAST IN CUTS.

13. Only the cleanest of gravel ballast should be unloaded in cuts to ballast track with. Where it is necessary (in order to get rid of them in the pit) to haul out on the track, together with the gravel, large stones, grass, sods, etc., they should always be dumped on an embankment where they will assist in strengthening the fill. If they are placed in cuts they must be removed after the track is ballasted so that the time spent at this work is wasted. This lost labor amounts to considerable when many miles of ballast is handled. There are very few gravel pits where an occasional train of clean gravel cannot be procured, and even where part

of the train load is composed of poor material, when unloading it, the worst cars can be cut off and left outside the end of the cut, and the cleanest gravel unloaded inside.

HAVE THE TRACK READY.

14. When ballasting track or raising it to surface, the foreman should so arrange his work that he will have the track ready for trains when due to pass there. He should make a "run-off" at the last rail of track raised, and outer ends of ties should at least be tamped up before a train is allowed to pass over it. The length of the "run-off" should be in proportion to the height the track is raised. Never make a "run-off" too short; it is better to flag a train and hold it until you are ready, than to risk surface—bending the rails, or wrecking the train. Foremen ballasting track should always protect themselves against wild trains by keeping a flag out against them and off the time of regular trains.

HIGH RAISING.

15. When track is raised more than six inches high, to put ballast under it out of a face, the foreman employed to do the work should be thoroughly competent and reliable. One foreman should work the larger part of the surfacing gang, and with them lift the track, tamp the ties, and do a part of the filling, leaving the track behind him with a true surface, perfectly level and in good line. Working some distance behind the first gang another foreman with a smaller crew of men should do the finishing work. This gang should be about two days behind the first gang, so that any poor tamping or weak places may be fully developed. He should carry, besides his other tools, a full set of tamping bars and raise up to surface all depressions in the surface of the track made by trains which passed over

it after the front gang left it. Every piece of track taken up to surface by the second gang, should be tamped solid to a perfect surface with tamping bars, they should also put a true line on the rails and fill in the balance of the gravel, and dress up the sides and center of the track, moving all surplus ballast with their push car to points along the line where it is needed to make the shoulder of a uniform width.

GRAVEL FOR ONE MILE OF TRACK.

16. Allowing an average of thirty-three feet for each car length, including the space between the cars, one hundred and sixty cars of gravel will reach over one mile of track. If this amount of gravel is unloaded by hand, or plowed off from the cars, which is a better way, and if the trains average about eight yards of gravel to the car, there will be gravel ballast deposited along the track equal to six inches in thickness, twelve feet wide on top, and twelve feet six inches wide at the bottom, for the entire length of one mile of track. Deduct from the above amount of gravel about one-half for filling between the track ties and for dressing the center of the track after it has been surfaced up, and there is still left a balance of about three inches in thickness to be put under the bottom of the track ties.

If two cars of gravel are unloaded at one place, the depth of gravel ballast under the track ties is increased about threefold.

The only loss from the second carload of gravel is about one-twelfth, which goes into the side slope of the shoulder of the fill.

The second car leaves a load of gravel $8\frac{1}{2}$ inches in thickness beneath the track ties. This is a good argument in favor of ballasting with not less than two carloads of gravel in a place. One carload in a place

makes a very poor job, especially where it is put under the track without digging out the mud from between the ties.

Where the sub-grade is well drained and solid, a first-class track can be made by ballasting with two cars of gravel in a place, and to do the work in this way, estimates may be taken at the rate of three hundred and twenty-five cars of gravel to the mile of track. The embankment should not be less than fourteen feet wide on top, and should be made sixteen feet wide, if possible, before putting on the gravel, to prevent the ballast from washing away. Gravel may be loaded in pit for 75 cents per car, making the cost for one mile, one car to the rail length, about $125; in some pits the work may be done cheaper by building a trap and scraping the gravel onto cars with horses, or by employing a steam shovel.

LEVEL TRACK IN YARDS.

17. The track in all yards should be surfaced level throughout their entire length, and all tracks running parallel with each other should be of the same height when possible to have them so. When tracks have once been put to a uniform level surface, no part of them should be raised again higher than the rest of the yard unless it is intended to raise the level of the whole yard. Many inexperienced foremen, in charge of yards, think it is necessary every time they repair track, to surface it a little higher, and a difference of several inches in the heights of the tracks may be seen in some yards. This is a harmful and senseless policy and should not be tolerated.

HOW TO LEVEL YARD TRACKS.

18. A simple method by which to get tracks which run parallel to each other, to the same height, is as fol-

lows: First, put up the main track properly, then use a straight edge from the nearest rail of the adjoining track in order to raise it to a level with the main track. You can then move to a point several rails ahead on the main track and repeat the operation. After this you can raise and sight,—level the track on the siding between the two points which you have made level with the main track. A foreman can level a track lengthways somewhat in the same way as above described.

Rule.—Run the level and a straight edge on the top of two or three stakes running parallel with the track to be leveled, and do the same at a place some distance from that point. Then sight over the tops of the stakes at both points, and have a man drive stakes between the two places where you have leveled, until the stakes which he has driven are at the same height as those you have leveled with the level and straight edge. The top level of the stakes will be the level of the track rails. In important yards the company's engineers generally give level stakes for all tracks.

GRAVEL PITS.

19. A few words about the gravel pit will not be out of place in this book.

On roads where stone, or other kinds of ballast is scarce, or cannot be procured, a gravel pit along the line is very desirable. There are very few roads that cannot find at least one or two gravel pits along a division.

After the gravel pit has been purchased, and when the work of removing material is about to commence, the foreman in charge of the work should thoroughly examine the lay of the land and find out how his track must be laid in order to get the deepest face of gravel

to work on. Of course, at the same time, the best location for the track must be arranged for the accommodation of trains, and this should be done with a view to future improvements.

The track should always be longer than the face of the gravel in the pit, so that one, ten, or any number of cars could be loaded without danger of spoiling the line of the pit face. This is very important, because where a short track is put in on account of a handy place to put in the switch, or for the reason that there is not much gravel needed at that time, the face of the pit contracts and becomes so short that the loading place is only like a sink hole in the ground, and it soon becomes difficult for an engine to pull out of the pit more than two or three cars at a time, making necessary six or seven switches to do what could be done in one, with a good track. Besides this, there are other reasons why a short track should not be used. The men loading the gravel keep lining the track over as the bank recedes and there is soon a heavy curve in the track which follows around the edge of the excavation, so that it is only a short time until the track has to be torn up and the work all done over again. Now is the time the loss occasioned by gouging a hole in the bank is discovered. If the track is laid along the face of the pit, cars can only be loaded at either end of the pit, and there is loss of time from placing them, switching, etc., and perhaps the two ends of the pit next the track are not long enough together to allow a full train of gravel to be loaded at once, and there is no help for it except to work at the ends, until the gravel can be reached all along the track.

Another argument in favor of a longer track is that

the face of the gravel can be increased in depth by lowering the track.

Foremen in charge of loading gravel should see that the men load in one place until there is a space on that side of the track at least two or three feet lower than the ties and wide enough to let the track into it. It should then be lined over and the men could load on each side of the cars. Every foot that the face of gravel can be deepened makes the cost of loading it less, and reduces the proportion of top soil which mixes with the gravel. Men loading gravel on cars will load a greater number if paid by the car than in any other way. When the work of loading is not let to the men in the above way the foreman should divide his gang so many men to each car; this makes them compete with each other.

The steam shovel, with a sufficient number of trains of ballast cars, is the best equipment to use for economically getting out gravel from the pit to the place where the track is to be ballasted, and for distributing the same.

GRAVEL VS. WEEDS.

20. When ballast is scarce or the business of a railroad will not warrant an expenditure equal to ballasting the whole road, it is a wise policy to put gravel ballast on a part of each section, more especially on long sections with only small gangs of men to keep up the track. When other things are equal, the gravel or other ballast should be put on that end of the section which is farthest from the section foreman's headquarters. Besides the saving effected on a long section, by reducing the cost of cutting the weeds, the ballasted piece of track, being the best part of the road, will save for the company many dollars which

would otherwise be paid out for pumping the hand car the extra distance to and from work every day. The cost of cutting the weeds on eight miles of dirt ballasted track for one season, on many railroad divisions, would pay for the loading and hauling of gravel, or cinders, and putting in first-class condition two miles of track or one-fourth of the eight-mile section. Putting the ballast under the track in small quantities at a time in one place need not cost the company anything extra, as the section crews can do this as well as cut the weeds, and in most cases the work will be better done than by an extra gang.

KINDS OF BALLAST.

21. Locomotive Cinders.—These are used on account of their cheapness. In wet cuts they are very desirable.

Furnace Slag—This makes an excellent ballast, the principal objection being the difficulty of working when it takes a "set," owing to the lime contained therein.

Burned Clay*—This is principally used in the West. Almost any clay soil, easy to excavate, free from sand or vegetable matter, is suitable for ballast material. Gumbo probably makes the best, and requires less fuel to burn it than the brick clays. It is generally burned in piles, laid from two to four thousand feet in length, so placed as to be easily accessible by tracks. Fire is started with old ties or other wood, and when it is well under way the clay and coal are piled on in alternate layers, the clay being thrown up from the trench beside the fire. Various machines are used for this purpose. Some of them are on the principle of a

*This information about burned clay is taken from Roadmasters' Proceedings. Of the substance used, locomotive cinders, furnace slag, burned clay, gravel and stone are the most important.

conveyor, clay being carried up on a belt. This, however, tends to pulverize it more than is desired. There is a machine on the principle of the steam shovel, which digs the clay and places it on the fire in lumps, which gives better results as to quality of the ballast. After it has been burned it can be loaded by steam shovel or by hand. Coal, if economically used in burning this ballast, may be mixed as follows: Fifteen per cent. nut coal, 40 per cent. mixed coal, 45 per cent. slack. This mixture costs at some of the Western mines about 34 cents per ton, one ton of which will burn about four yards of ballast. The cost per cubic yard of ballast in the track is about $1.05, distributed as follows, the price for the first item being variable:

Contract price for burning	$ .38
Average cost of coal	.21
Loading on cars	.08
Distributing	.09
Putting under track	.22
Interest and depreciation	.04
Land	.01
Miscellaneous expenses	.02
	$1.05

Gravel—This is used to a great extent by the majority of roads, and when clean and about the size of a walnut gives most excellent results.

Stone Ballast—Within the past few years stone has been used very considerably as a ballast, and from it the best results have been obtained, provided proper care has been exercised in its selection, as regards size and material entering into its composition. Undoubtedly traprock and limestone are superior, as a soft material like ordinary sandstone breaks up and crumbles under working, forming in time simply a mass of mud under the ties. An excellent size is such as will pass

through a $1\frac{1}{2}$-inch ring. This will offer sufficient interstices to allow all water to pass, and is easily worked.

Experiments have been made with three different sizes of traprock ballast. A bucket holding 12 quarts of water was taken and filled level with the top with stone that would pass through a $2\frac{1}{2}$-inch ring; water was then poured in, and it held $6\frac{1}{2}$ quarts. Then a half-inch smaller size was taken, and the same operation gone through with, and it held $6\frac{1}{4}$ quarts. Then $1\frac{1}{2}$-inch ballast was taken, and the test showed that it held 6 quarts.

In order to get a comparative estimate of the velocity with which water would drain through these different sizes, under similar conditions, the same bucket was used, and four five-eighths inch holes bored in the bottom, 90 degree apart. By pouring in the same amount in each case, which was 6 quarts, with the coarse stone it passed through in 20 seconds, with the next size in 22 seconds, and with the smallest in 24 seconds. A larger stone is not so good for tamping as one of such size as will pass through a $1\frac{1}{2}$-inch ring. At times the road bed will get into such condition as to retain water, and in this event, the smaller the stone the more solid will be the foundation, and the less amount of water it will hold.

In view of these facts, it is conclusively proven that a small stone is much more profitable for ballast than a large one. And further, if the specifications require the size of ballast to be such as will pass through a $1\frac{1}{2}$-inch ring, the large stones which meet the requirements in two dimensions but are large in the third, will be kept out.

One of the uses of stone ballast is to arrest the springing action of the track, and to accomplish this, the deeper it is below the tie the more solid the riding

will be. In no case should this be less than 12 inches, and if it were 2 feet decidedly better results would be obtained. Stone of the proper size and of sufficient depth will give more stable track than any other material that can be used for ballast. And, besides this, the drainage is nearer perfect. Care must be taken to have it properly screened at the quarry, so as to be as clean as possible.

The one thing, above all others, which stands in the way of its use is, first cost and labor necessary to place it in position. A cubic yard will range anywhere from $1 to $1.20 in place. Considering a mile put up at the higher figure, it will require the expenditure of $4,200.

The first cost of stone ballast being the largest item that faces the engineer in track laying, great care should be exercised in its selection; but after it is once in place and thoroughly tamped, provided the roadbed causes no trouble, it is as solid as the rock of Gibraltar.

HANDLING OF BALLAST.

22. In the majority of cases stone is unloaded by hand, but there are several devices to do away with this, and thus cheapen the first cost. The more important of these are the Rodgers ballast car and the method employed by the B. & O. R. R.

The B. & O. method is thus: The contractor furnishing the ballast quarries and crushes the stone, delivering it on his own cars. The road furnishes the engine to haul these to the point of delivery. The contractor supplies the plow, cable and stationary engine on flat-car for operating, taking steam from the locomotive boiler to operate his engine in running the plow, for all of which he receives 75 cents per cubic yard. The measuremeants are made by weight. They had constructed a box 3 feet cube; it was filled with

crushed stone from each of the quarries and weighed; the weight of this stone was taken as the standard for the weight of a cubic yard of crushed ballast from any particular quarry, and upon this basis they paid for all stone received.

CHAPTER VIII.—RENEWAL OF RAILS.

LAYING NEW STEEL.

1. When steel rails were a new thing, and cost several times as much money per ton as they now do, the railroads which purchased them were very careful where they laid them and how they were laid. The track had to be ballasted, smoothly surfaced, and filled up with good, sound ties, especially under the rail joints.

None but the best of trackmen were employed to do the work, and special instructions were issued to the foremen how the rails should be handled and laid in the track; and the correct space between joints at the different temperatures was given, which could not be varied because expansion shims were furnished to be placed between the rails when being laid. Special provision was made for unloading the rails from cars without bending or twisting them. No kinky rails were put in the track in that condition, and a record was kept of the wearing qualities of each separate lot of steel rails. It was considered next to a sacrilege to cut off the end of a steel rail to make a connection or put in a new switch lead, the iron rail always being cut in preference, or proper lengths of steel being furnished for the switch lead. The results, in most cases, fully compensated for the pains taken when laying steel rails, and most of the railroad men who have had experience doing this work can testify that rails so well

taken care of remained in service and lasted almost double as long a time as some of the steel rails laid nowadays. This in part may be attributed to the inferior qualities of some of the steel rails produced at the present time.

Steel rails have become so common now that all new railroads constructing or old roads relaying their track use nothing else, and on many of these roads (although there may be a pretense to the contrary) the steel is often thrown down on rough grades and run over without ballasting. In fact, the policy of those in charge of the work seems to be, in some cases, not to take any better care of the new steel than they would of old, worn out iron. Although steel has now nearly replaced iron rails, the regulations for laying it, such as those mentioned in the beginning of this article, should not be altered in any particular. June, July and August are the best months for laying steel rails in the North and West, because during the summer months the conditions are more favorable for improving the track. The ground is dry and subgrade solid. Ties are all in the track, or on the ground ready to be put it. Ballast supplies can be easily reached. There are better facilities for furnishing locomotives and cars to do the work, on account of lighter business on the roads. Last, but not least, the new rails may be laid at a time when there is the least variation in temperature and they are at or near their greatest expansion.

HOW TO RELAY STEEL.

2. The method most generally practiced by trackmen, when relaying steel, is as follows: First, the rails to be laid are ranged out along on the ends of the ties not bolted together. The work of ranging out the new rails and getting ready to lay them into track should be

done while trains are running so close together that there is not time to change a very large number at once. The time to put in new and take out old rails is when there is the longest time between the passage of trains over track during the day. Another part of the work in getting ready is to remove from the rails in the track all the bolts and spikes that can be taken out with safety. When everything is ready to lay in the new rails, a part of the men remove all of the spikes remaining in the track on one side of each rail. The inside spikes are generally the ones pulled out except when there is a difference in the width of the track and outside spikes on the other, or on both sides, in order to have the new iron or steel come to perfect gauge. While a part of the men are pulling spikes, etc., another part should be throwing out of place the old line of rails and at the same time more of the men should be dropping in the new line of rails and others bolting and spiking them into place. Everything should be kept moving so that when the next train is nearly due there is nothing remaining to be done but making the connection between new and old rails where you intend to leave off, until the next line of new rails is ready to put in. The custom also prevails among some roadmasters and foremen of bolting the rails together before they are placed in the track. This is a mistake for several reasons. The principal objection is that the proper expansion cannot be kept between the rails. Also, if you wish to close up suddenly, there is the extra work of unbolting one of the joints.

In laying new rail it is best to put in place one at a time; it is as expeditious as any other method, and better results are obtained. When a foreman wants to make his temporary connections to let trains pass, a

much better and quicker method than the old way of cutting a rail, every time a connection has to be made, is to keep on hand, ready for use, two rails about ten or fifteen feet long, cut tapering to a point on one end like those in split switches. When you want to make a connection you bolt the blunt end of these rails to the end of the last new rail put in, and lay the point end of short rail close up along the side of the next old rail, holding it to place with a shoe or clamp and spiking it to gauge. To put this short rail to gauge it is necessary only to pull or spring the spikes enough to let the end of the old track rail spread a little, and let the point rail to gauge. The use of these two short point rails saves considerable time in making connection, as a foreman can work his men close up to the time that a train is due, putting in the new rails. An ordinary switch point can also be used for this purpose. If the new rail is of heavier section than the old, a good way is to have a six-foot piece of the new rail bolted to a switch point of the section of the old; then when it is desired to close up temporarily, this arrangement can be put in place very quickly. On double track roads always lay the rail so that trains will trail over the temporary connections. Never leave a switch point, used as just described, in the track over night. Always connect up the track properly before leaving it for any length of time. If joints are not furnished quick connection may be made by lapping the old and new rails in the same way a joint is used, except that the inside rail should be one-half inch light gauge and point in the direction the train is going.

Where there are many trains passing to interfere with the work of laying rails, to put the rails in track in a string is the most economical method; but where

few trains are run and steel gang can use nearly all the day for work without interruption the method of laying one rail at a time is the most economical and best way, as we have the added benefit of only handling the rails but once, and maintaining better expansion, as said above.

Whether a gang lays steel one rail at a time or in a string makes little difference in the distribution of expansion, if the foreman knows his business. The most damage is done to track by unequal distribution of expansion caused by not putting in the joint ties and slot spiking the angle bars to them as fast as the work of relaying the rails progresses.

AVERAGE LIFE OF STEEL RAILS.

3. Owing to the difference in quality and in the amount of traffic over steel rails, it is very difficult to form a correct estimate of the average life of the same.

An important item to be considered when figuring the life of track rails is the care they received when first laid, and how they were kept up to surface by the section men afterwards. Rails that are properly laid and are afterwards kept up to a good smooth surface, will wear and give good service from two to five years longer than rails of the same grade which have only been indifferently cared for. Every year that the life of a rail can be prolonged, it means a saving to the company of the interest for one year on the principal invested, and a proportionate part of the original cost, which is sometimes equal to the difference in value between old and new rails, and in many cases the amount thus saved would pay for the track labor for several years.

Good iron rails have been known to last, in service on the main track of a railroad doing a fair business,

eight and nine years, and steel rails fifteen years, but many brands wear out in less time.

When their ends have become battered, rails are of little value in the main track of any road, where there is much business, and the joints cannot be kept up to a good surface, no matter what kind of ballast is put under them. The only remedy is to saw off the bad ends of the rails and use them in branches or side tracks, and when the rail is battered on both the joint and center, it is only fit for rolling mill scrap. Track foremen should always remember that by keeping a smooth running surface on the rails is the only way they can demonstrate their superiority as good trackmen. For such men there is always employment and good wages. One of the largest items of a railroad's expenses is caused through neglecting to keep a smooth surface on the track joints, either on account of incompetent foremen, or insufficient track forces.

EVEN OR BROKEN JOINTS.

4. There has been considerable discussion by trackmen on the subject of broken or even joints. The majority of track has heretofore been laid with even joints, but there lately have been many opinions expressed in favor of laying rails with what are called broken joints, which consists in placing the rail joint on one side of the track opposite to the center of the rail on the other side of the track. There are a few points in favor of the latter method which are of sufficient importance to be worthy of consideration.

On a curve track where the rails were not curved before being laid, the broken joint will assist to keep the track in line, because the center of the rail will retain the curve better than the joint; but if the rails are curved to the proper shape before being laid, the true

curve line can be preserved as well without broken joints. It is also claimed that when the rails are laid with broken joints a better surface can be preserved at the joint, the smooth rail center on the opposite side preventing the car wheels from striking the ends of the rail so hard when passing over it, and this seems to be the chief reason for laying the rails that way.

On the other hand, it is handier to lay track with even joints and to repair and surface it. Even joints on a rough track will remain level, and trains will ride smoother over them than would be the case over a track laid with broken joints under the same conditions. But a rough track on any railroad ought soon to be a thing of the past. Laying the rails broken joints doubles the work of placing joint ties and spacing them.

DEFECTS IN STEEL RAILS.

5. A self-evident fact is that the rail of the present day is not of the good quality of ten years ago, owing to its not being worked enough at the mill.

Outside of the general line and surface, the principal evils are pipes, gag marks and cinders, which result in flaws. A pipe is caused by air bubbles in the metal, and when the rail is worn a certain amount this causes weakness, and consequently the head either cracks, or, if near the end, flattens out. Putting this through the rolls an extra time or two would have undoubtedly obviated it; or the same result could be accomplished by working it at a higher temperature.

Gag marks occur in straightening the rail, and when they show themselves in the head cause great difficulty in keeping up the track, owing to the jolting motion imparted to the car.

Cinder in the molten metal causes defects after the

rail is rolled, in the nature of flaws and subsequent cracks.

RAIL SECTIONS.

6. As to the proper section there are a variety of ideas. The American Society of Civil Engineers, New

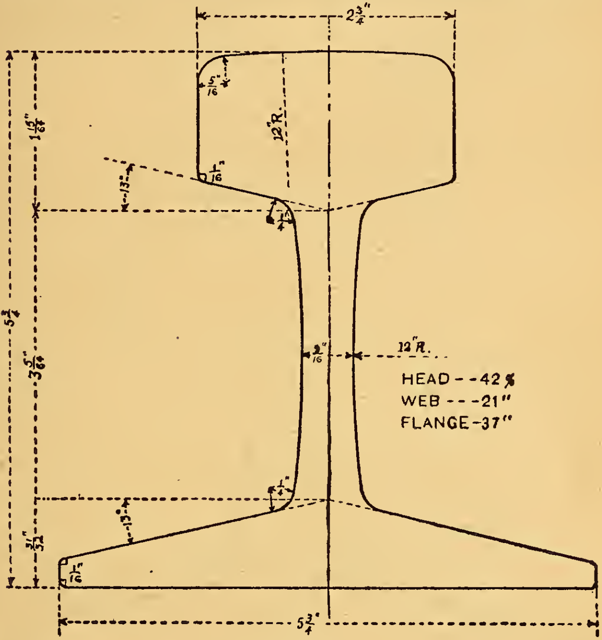


FIG. 22.

York Central, New York, New Haven & Hartford and Pennsylvania 100-pound sections are herewith given; their characteristics are shown by Figs. 22, 23, 24 and 25.

Owing to the heavy engines and cars of great weight being demanded by the traffic department to carry freight profitably, heavy rails are demanded to be used on the trunk lines of all railroads, and as the

height gives vertical strength, in such heavy rails used, height should be the first consideration; at the present time six inches is giving good results. To give good wearing heads to such heavy rails, the proportion of metal in its head should be kept down to the minimum, as, owing to the present process of rolling steel rails at very great heat from a large ingot, a

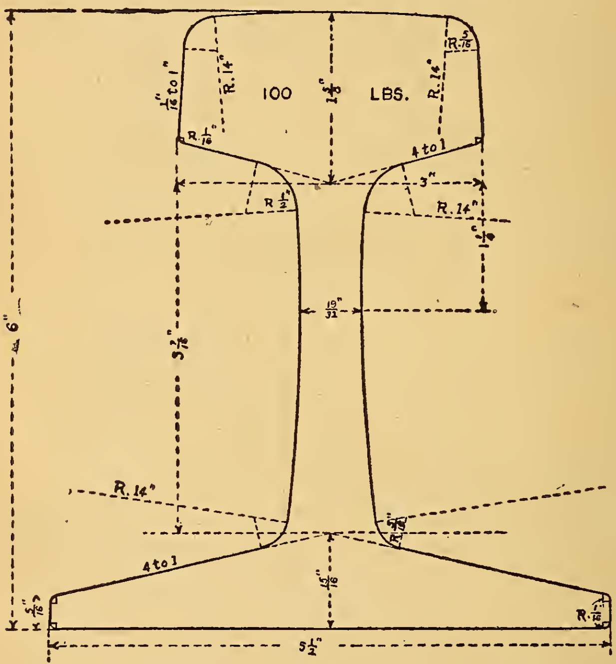


FIG. 23.

thick head will not give as good results as a thin head rail; and, though theoretically the base should be as wide as the height of the rail, it is being admitted at the present time, to get perfect base rails and allow the metal in the head to be homogeneous throughout, the rail base will have to be of less width than the height

of the rail. The web should also be thicker at the base than under the head, which in the high rail insures greater strength, as the tendency is to break at this point, if too weak.

LEAVE CORRECT EXPANSION.

7. Particular attention should be paid to the opening between the ends of such heavy rails, so as not to

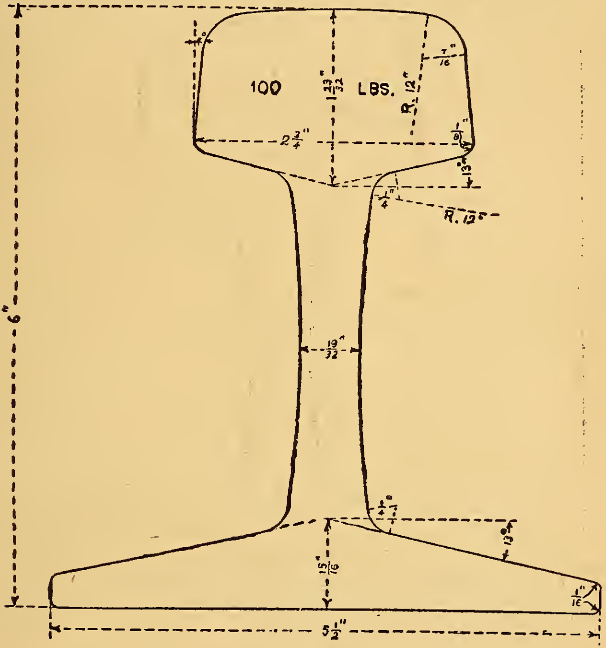


FIG. 24.

allow them to become open only far enough as contraction demands in the coldest weather. This can only be accomplished by having the holes in the ends of the rails correctly drilled as regards their centers from end of the rail, and seeing that the bolts used to attach the joint to the rail ends are not in any position

but square across from outside of one bar to the outside of the other joint. This means a tight fit for a cup-head oval-neck bolt in the bar in which it rests, and reduction of the size of hole in the other bar in which the thread of the bolt lies.

In the laying of steel, particular attention should be paid to the opening left when rails are laid, governed

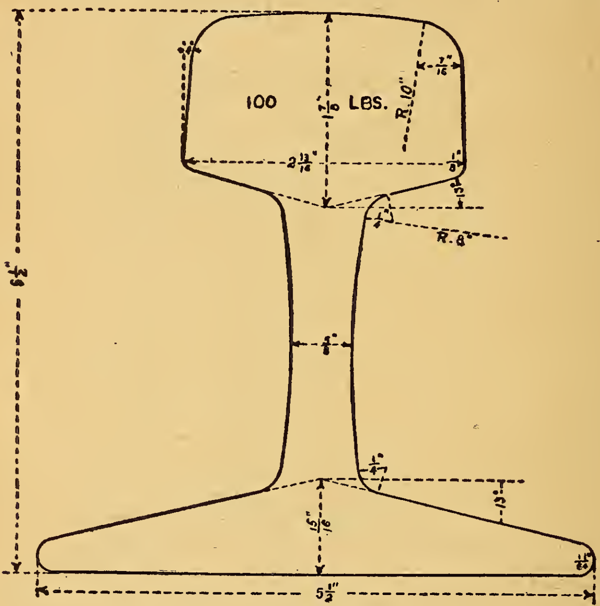


FIG. 25.

by the temperature at time of laying. This opening will become distorted unless the joint ties are tamped up into position and slot spikes driven in as designed to hold the opening between the rails as laid. This space between ends should be reduced to the minimum, which at low temperature should not exceed ⅜ inch.

The length of rail generally used is 30 feet, but lately there have been experiments made to increase this. The Lehigh Valley Railroad have placed in track 45-foot lengths, while the Pennsylvania have increased this to 60 feet. The advantage of the former is that there are 33 per cent. less joints, and the latter 50 per cent. The disadvantages are the difficulty of handling and the amount of opening which has to be left for expansion.

CHAPTER IX.—EFFECTS OF THE WAVE MOTION OF RAIL ON TRACK.

RAIL MOVEMENTS.

1. As all the rail movements are on the principle of the lever, there is, of necessity, a rising and falling of same, or, in other words, an undulatory motion on the passage of every train, the principle of which is illustrated in Fig. 26. The amount of this is dependent

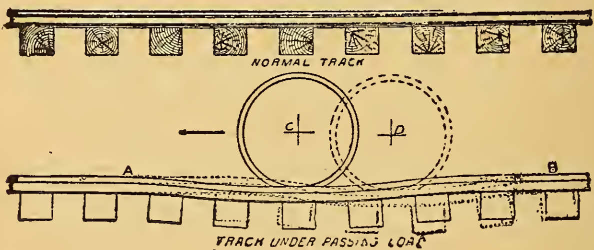


FIG. 26.

on the condition of the sub-grade, ballast, ties, rail and weight of the rolling stock. Any weakness in the drainage, ballast, ties or rail will at once show itself when put in use. If not corrected at once this will enlarge, and the destruction it can cause is liable to be serious. The less substantial the superstructure the greater ballast compression there will be, and, of necessity, rough-riding track.

If water is permitted to lodge under the ties, in a

short time they will churn, and, unless taken care of, will prove destructive.

Movements or vibrations of any kind are objectionable in the track; and for that reason wood and stone are used to absorb these as much as possible.

The undulatory motion of the rail has the following injurious effects:

1. Compresses the tie in the ballast.
2. Churns the ties.
3. Displaces the ballast.
4. Injures the roadbed.
5. Injures the rail.
6. Wears the angle bars.
7. Wears the bolts.
8. Raises the spikes.
9. Cuts the ties.
10. Wears the spikes.
11. Wears the rail.
12. Causes the rail to creep.

BALLAST COMPRESSION.

2. The different functions which a tie performs must be taken into consideration.

1. It holds the rails to gauge.
2. Supports the rails.
3. Must be stable in the track.
4. Distributes the weight of the passing wheel loads to the ballast and roadbed.
5. Resists compression into the ballast.

It is claimed by many that the ties act as abutments, and the rail deflections occur between these. From practical experiments this is an error; and as the Pennsylvania Railroad have recently been making

tests in this direction, the letter from Mr. Bland, which is quoted below, will substantiate the above statement.*

The thought now is to get the most perfect form of tie to best distribute the weight of the passing wheel loads to the ballast. Abroad, the frustum form of support is used to a great extent, and this form has been long and favorably known by engineers for distribution of concentrated loads.

CHURNS THE TIES AND DISPLACES THE BALLAST.

3. The foundation of all ties being loosely compacted material, any movement of the tie, or what is commonly called "churning of the tie," necessarily throws unequal loading on the ballast at different times, causes its compression and movement, and destruction of the tie foundation. The wider the ties and the lighter the rail and the heavier the loads, the greater such movement must necessarily be.

Assume, for instance, two wide ties and a light rail,

*"The circumstances to which you refer, and of which you ask definite information, were as follows:

"For about two weeks during October, 1898, we had an 'L' engine on the Pittsburg Division of the P., C., C. & St. L. Ry., for trial. This engine was of an eight-wheel class recently built by the P. R. R., for its fast and heavy passenger service. The weight was as follows:

On front pair of drivers	48,300 pounds
On rear pair of drivers	45,300 pounds
On standard truck	41,700 pounds
Total	135,300 pounds

"Some apprehension being felt as to the effect of these heavy wheel loads on our track, the Chief Engineer, Superintendent of Pittsburg Division, Engineer Maintenance of Way and myself went out on the lines, rode on the engine and made some observations as to deflection of track under passing load. At a speed of fifteen miles an hour we found the track, as a whole, deflected (or, rather, subsided in the ballast) from 5-16 to 3-8 inch under the passing wheel load, which was, as you see, 24,000 pounds. It was also very evident that nearly all of this deflection was due to the subsidences of the ties in the ballast, and not to bending or deflection of the 85-pound rail. Computing the deflection proper for 85-pound rail under a 24,000-pound wheel load, I found it to be 1-200 of an inch, an amount not discernible with ordinary measurements. The conclusion reached by us all (and which has been verified by other observation) was, that what we needed for the constantly growing weights of engine driver loads was not heavier rail, but better tie support; that is to say, more ties per rail to lessen the spans, and a width of tie proportionate to the heaviest driver load in use on the line in question."

and over them a heavy wheel load, midway between the ties. This rail will bend under these conditions and take the form of a curve, thus throwing the wheel load on the near edge of each tie, producing an eccentric loading of the tie, greater compression under the edge of the tie that is loaded than on the opposite edge, and, necessarily, a slight movement of the tie to adjust itself to these conditions. When the wheel moves to the opposite side of either of these ties the conditions are reversed, and thus the churning takes place. If these ties could be made of a triangular section with the rail bearing on the apex of the triangle, the disturbing action illustrated above could not take place. As ties cut in this manner would, of course, crush and be practically useless, the frustum is the next best form, and is consequently recommended. (See chapter on tie plates.)

INJURIOUS TO THE ROADBED.

4. This is a necessary sequence of the ballast displacement, and is augmented by the amount of water standing in pools on the bed.

INJURIOUS TO THE RAIL.

5. According to Professor Dudley, rails take a permanent set, as regards wave motion, in one of three forms:

1. Joint low and center high.
2. Joint and center low, quarter high.
3. Entire rail wavy.

The first occurs in rails which are laid with the joints square or opposite; consequently the low places are found at the weakest point, the joints, while the centers are high.

The second form is met with in rails which are laid with their joints broken. The weak point being the

joint, they deflect in time, and it also appears in the opposite rail, which is at the center. And on this line of reasoning, if it is low at one point it must be high at another, which are the quarters.

The third form appears in the rail where the ties have been tamped unevenly, there being alternate hard and soft spots in the bed.

WEARS THE ANGLE BARS AND BOLTS.

6. At the joints there are several parts working independently—the two angle bars, the bolts, nuts, nut locks, rails, ties, and, to a certain extent, the spikes and ballast. Now, the least particle of vibratory motion destroys the mutual relationship between these parts, and a consequent wearing is the result. The principal wear is on top and underneath the bar, where the rail rests, and, in turn, where it rests on the rail. The bolt holes are also enlarged. The bolts, being a portion of the joint fastening, also wear, and in time are unfit for use

RAISES THE SPIKES.

7. As the vibratory motion of the rail takes place, something has to give way. If the fastening to the tie is by push bolt or lag screw, the tie will be raised with the vibration and "pump" the ballast. This action will take place for a while, but in time these fastenings will become loose. If the rail is held down by a spike, the tendency is to raise it an exceedingly small amount, enough to allow for the play of the rail. Spikes are either re-enforced under the head or perfectly plain. It is at this point that the re-enforcement is injurious, for whether it is in the back or front of a spike, raising it affords the rail an opportunity to move laterally by the amount of extra metal in the neck. As the re-enforcement inclines toward the vertical axis of the spike

as it extends down the neck, the farther it is extracted from the tie the larger the opening is left for the spike to fill up; and it is owing to this that the spike is crowded backwards in the hole and the rails have a chance to spread. In short, there should be no re-enforcement on the neck of a spike.

TENDENCY OF RAIL TO WORK INTO FACE OF TIE.

8. When the spike is slightly higher than its normal position in the tie, the rail has an opportunity to act on the tie more so than otherwise. This action partakes of three different forms:

1. A straight pressure downwards.
2. A lateral pressure.
3. A resultant of these two.

WEARING THE SPIKES.

9. The rail has an opportunity to work up and down, wearing the neck of the spike. The same action takes place when a spike is not driven properly.

WEARS THE RAILS.

10. When a rail is canted, all the running is done on one side of the head, and, consequently, this is where the wear takes place.

RAILS CREEP.

11. Creeping is caused by the undulatory motion, and is very destructive to track. Not only does it buckle the joints and tear apart the bolts, but also disturbs the ties, especially those at the joints, and, of necessity, displaces the ballast.

This is arrested in part by the slot holes in the angle bar, but stops of some sort should be used in addition; these can be in the form of an angle bar about six inches long, with slot holes for the spikes. One bolt can be put through these, and the bar attached to the middle of each 30-foot rail. In stone ballast, tamping ties on the leaving side materially assists, as well as driving the outside spikes on the receiving side.

CHAPTER X. — GENERAL FALL TRACK WORK.

TOUCHING UP.

1. Track foremen will find plenty of work to do during the fall months before the ground freezes, preparing their sections to go through the long winter months with as little repair work as possible. If the weather is good more work can be done (which will benefit the track) in one month before the ground freezes than can be performed during the whole winter.

Section foremen should find all the worst places in the track and repair them in the best manner possible.

Special attention should be given to improve the surface of the track and putting a perfect line and gauge on the rails.

The roadbed should be cleared of weeds and grass and the ballast along the shoulder of the track and between the rails should be dressed up neatly; joint fastenings should be made tight, and the ditches in all cuts should be cleaned out.

Any rotten ties remaining in the track should be taken out and replaced by new ones.

All new steel should be laid before cold weather. The joint ties should be spaced properly and ballast put under the track, and at other points on the road where steel is not laid good repair rails should be put into the track to replace those which have become battered. Grass should be cut while still green and no

rubbish allowed around the wood work of all bridges, culverts or cattle guards, and the rubbish should be gathered up and burned.

In a prairie country the grass along the right of way on both sides of the track should be burned off clean as quick as it is dry enough, and the tops of the cuts should be burned off first, to prevent the locomotives from setting fires on farm lands adjoining. All right of way fences should be examined and repaired and snow fences should be put in good condition to be ready for the first snow storm. All track material should be piled at the stations, a safe distance from the track, and where it would not cause snow drifts, or be liable to catch fire.

Rails, splices and such other material should be raised from the ground and piled upon platforms of old ties so there will be no difficulty in handling them after snow falls on the ground.

All ties, fence posts, engine wood, or lumber should be corded up with spaces between the piles so that in case of fire it could not communicate to a large quantity at once. Emergency rails and joint splices should be placed at the mile posts along the section, where they would be handy in case of broken rails. Much of the fall track work is the same as that done during the spring or summer. But foremen should be particular to do this season of the year all work which can only be imperfectly done in the winter or must wait over until the following spring.

CLEANING THE RIGHT OF WAY.

2. In the latter part of the month of July, or before the weeds growing along the railroad right of way run to seed, provided State law requires it, the section foreman should commence mowing, and cutting down

all grass, brush and weeds from the shoulder of the track out to the right of way limits. This work should be pushed when once begun, and as soon thereafter as the material which was mowed down is dry enough, it should be gathered into piles and burned clean, or disposed of in some way, without danger to the company's property.

The grass and weeds growing around the ends of culverts, or close to the bridges, should be mowed down, while the surrounding grass is still so green it will not burn, in order that the mowed grass, when dry, may be burnt without danger of the wind spreading the fire, and to prevent other fires from reaching the wood work when burning off the right of way afterwards. In localities where the sections are long, and only a small force of men is employed, the right of way mowing is sometimes only done for a short distance out from the shoulder on each side along the track, and the balance of the right of way is left to be burnt off later in the fall.

RAISING UP SAGS.

3. It frequently happens that a track foreman will undertake to raise the track in a sag up to level surface without any knowledge of the amount of material necessary to put under the track or the time it will require to do the work with the force at his command. In some cases, the time consumed in taking up a sag is so great that other parts of the track which should be attended to are neglected. The following simple rule will enable track foremen to make a very close estimate of the amount of labor and material required to bring any sag up to surface.

Rule:—Set two stakes, A and B, close to the track rails and level with their top surface at each end of the

sag, as shown in Fig. 27. Then set a third stake C at the middle of the sag and in line with A and B, and drive it down until the top of it is level with the tops of the outer two stakes. You can ascertain whether this is the case by sighting over A and B. Measure the height of stake C above the ground and multiply it by the distance in feet from A to B, and again multiply the product by the width of the embankment in feet and divide by 2. This will give you the contents in cubic feet and dividing the whole number of cubic feet by 27 will be the number of cubic yards of dirt or ballast which will be required to surface up the sag. If the sag is deeper than twelve inches an allowance of one

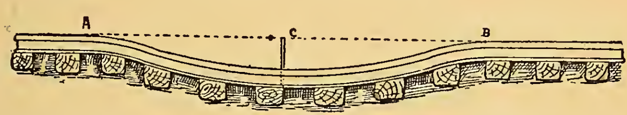


FIG 27.

foot in width for each foot in depth should be made up for the side slopes. An allowance of about one-sixth of the depth above level in some cases should be made on the middle of light sags when surfacing up. This can best be done by leveling a sight board the proper height in the middle of the sag and sighting the track to it from one end, and from that point sighting the rails to where the sag runs out at the other end. A sag, which has only been raised level with the track on each side of it, will soon become low again in the middle unless made very solid.

NARROW EMBANKMENTS.

4. Many section foremen have a habit of digging holes in the embankment just outside the ends of the track ties when they want a little dirt or ballast to pick

up or dress the track. This is all wrong, and can be justified only in case the traffic over the line is so heavy that it is not advisable to attempt to haul dirt with a push car On a mud track if material is wanted for this purpose it should be taken from the nearest cut with the section push car, or if the fill is not very deep the foreman should set his men throwing up dirt from outside the bottom of the original fill. There the necessary material can be procured without injuring the embankment sufficiently to make it liable to wash away, or weakening it as a support for the track. The preference should always be given to material from a cut even when the cost is a little greater. A double purpose is served by removing the surplus which accumulates in the ditches and putting it on the fill to strengthen it. Of course, where track is ballasted with gravel, or other like material, dirt should not be mixed with it, but when only a small quantity of material is needed it can be taken from places where the ballast is the heaviest along the shoulder of the track. Whenever any material is taken from a grade or wasted therein, such places should be leveled off, dressed and finished up in a workmanlike manner. Never leave unsightly holes along the track. Both sides of the embankment should be the same width outside the ties, if possible, and grass should be encouraged to grow along the slopes, because it offers the best protection against weeds and washouts. Section foremen should not attempt to raise up track on high, narrow fills in order to surface it. At such places it is always best to pick up and tamp only joints or other low places in the rail, and keep the track in good line until you can get enough dirt or ballast to leave a good shoulder outside the ties after raising up the track to surface.

HAUL OUT MATERIAL FROM CUTS.

5. Where the distance between cuts is short, and the track fill between is high and narrow, section foremen should make good wide ditches in the cuts, and haul out on their push car the material from the ditches, and distribute it evenly on both sides of the track. This work should be done either early in the spring, or late in the fall of the year, or when the facilities for doing other work are not good.

TO REMEDY TOO WIDE AN OPENING AT THE JOINTS.

6. Track is often laid with too wide an opening at the joints, and as a result the ends of the rails batter down very quickly and the joint splices often break and tear apart, owing to the contraction of the rails in extremely cold weather. Track foremen who are troubled with this state of affairs should try to remedy it at once in the following manner:

Loosen the bolts in forty or fifty joints and pull out all the slot spikes which are used to control the expansion. Then select a space about midway to take out one or two of the rails on each side of the track. Have ready to replace the rails which you take out, one or two rails the combined length of which will be six or eight inches greater than that of the rails which you take out, allowing this length to be a little less than the total amount you wish to close the joints. Have your men get astride of one loose rail, lift it up and bunt back the track rails on each side of the opening until it is wide enough to admit of putting in the longer rails, then bolt and spike the rails to place, dividing the expansion on the other joints afterwards.

Follow out this method at different points along your section wherever you see it is necessary, and you

will have no more trouble with rails tearing apart in cold weather, endangering trains and increasing your responsibility. The rails will wear much longer, and you can keep a much better surface on the track. But foremen should exercise judgment in this matter and be sure that the expansion is so distributed that there will be no danger of making the joints too tight for warm weather.

When you have fixed a piece of track the above way, if supported joints are used, provide some new ties and put one into track under the center of every rail joint which has been moved out of its place on the track ties, when you were shifting the rails. If the joints are suspended square all the ties which have been shifted.

Both jobs should always be done at the same time and low joints tamped up to surface, the ties spaced properly so that the spikes may be driven in their proper places and prevent track creeping.

CHAPTER XI.—FENCES.

BUILDING FENCES.

1. It is sometimes the duty of section foremen to build wire fences along the railroad right of way limits; and as there are many foremen who have had no experience in this branch of work, it will not be out of place here to give a good, practical method for performing this duty.

Measure with a tape line from the center of the track to the right of way limits, which is generally fifty feet, and set a stake in the ground. This should be the outside face of the fence posts when set in the ground. Where the track is straight these measurements need be taken only at distances of forty or eighty rods, but around a curve they should be taken every sixty or hundred feet, in order to have the fence conform to the line of the track.

Peel the bark from all fence posts and set their centers sixteen feet apart, when not otherwise ordered, so that boards may be nailed on them if desired. To line the fence and regulate the distance between posts, use a chain or line two hundred feet long for straight track, and one hundred feet, or less, for curve track. Have tin tags at regular distances on your chain, or tie knots in the line to mark where the center of each post hole should come, and when the line is stretched take a spade and remove a little of the sod or top surface of the ground opposite the marks on the line as a guide

for the men digging the post holes. The line may then be moved ahead.

Set all posts two and one-half feet in the ground, and have the men who are digging make a mark on their shovels by which to determine the correct depth of the post holes, and thus have all the posts of a uniform height above the ground. A good way to save sighting along straight track is to set a post every forty to eighty rods with a temporary brace, and stretch one wire of the fence to use as a guide to set them by.

When putting on wires, if you are not furnished a wire stretcher, the wire may be tightened by taking

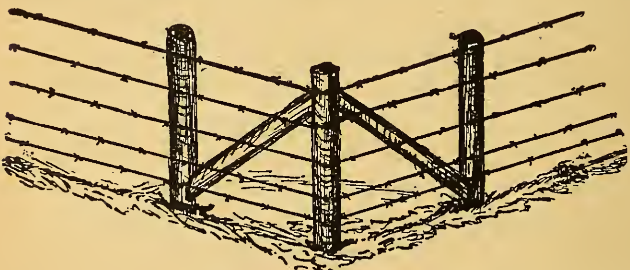


FIG. 28.

a turn of it around a lining bar. Stick the point of the bar in the ground diagonally from you, and pull on the top of bar with the right hand. In this way you can take up the slack.

Fence wire should not be stretched too tight in warm weather, or it will break when it contracts in the winter. Always put the wire on the farmer's side of the fence posts. A good brace should be put in at the end of each piece of fence, or at any point where the fence turns an angle at the end of fence, also at farm gates and cattle guards. See Figs. 28 and 29.

Mortice one end of the brace into the top of the corner post, and the other end into the bottom of the post adjoining, where it enters the ground. Provide a board with notches cut into it at distances equal to the proper space between the wires. The wires may be hung in the notches, and the board will keep them in position while they are being fastened to the posts.

Have the men well organized. Divide a gang of sixteen about as follows: Assign two men to lay out the fence; six to dig post holes; four to set the posts;

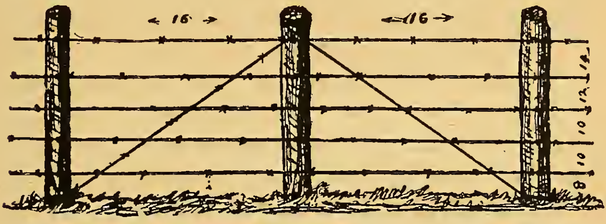


FIG. 29.

and four to string the wires and fasten them. Move the men occasionally from parts of the work which are the most advanced to parts which are behind. When crossing creeks or marshy places it is well to turn the fence in at right angle to end of the bridge and string the wires across on the piles.

Order material as follows: Fence wire, one pound for every single wire panel of sixteen feet; staples, one and three-fourths pounds for each hundred pounds of wire used.

When spacing wires, have the bottom ones the closer together. For instance, for a five-wire fence four and one-half feet high, place bottom wire eight inches above the ground; the second wire ten inches above the first, and the other three wires each twelve inches above the last, or the third wire from the bottom

could be spaced ten inches above the second, and the top wire fourteen inches above the fourth. The latter is the best method where it is desirable to fence against all kinds of stock. The top of fence posts should not be more than six inches above the top wire of the fence, and all posts when set and tamped solid should be in perfect line and a uniform height from the ground. When posts are irregular in length, the surplus timber should be sawed off if it amounted to four or more inches, but where the post is only two or three inches too long, the hole may be deepened sufficiently to leave it the proper height when set.

If a post is two or three inches short fill up the hole sufficiently to bring it to the right height above the ground. But should it be as much as six inches too short, do not use it in the fence except at some places where it would answer for a short brace. To regulate the height of fence post above the ground, have a standard made the correct height, and nail square across the bottom of it a cross piece two feet long, which will prevent slight inequalities in the surface of the ground from affecting the height when placed beside the post. This standard can also be arranged to regulate the distance between the boards or wires as they are nailed on the fance.

A fence with the top wire or top board four and one-half feet from the ground is a lawful fence in most of the States.

BOARD FENCES.

2. In building a board fence, the setting of posts and nailing on of the boards can be done at the same time. Always use the shortest boards to measure from one post to the next one to be set; the longer boards can be sawed the proper length. Nail the boards on

at the outside of the fence. Several men can be nailing on boards at once, by ending the boards against those last nailed on the adjoining panel. On straight track, sighting posts can be set at the proper distance from the track, every forty or sixty rods ahead of the men digging the post holes. But on curve track, to make a good fence and have it in line, every panel post should be measured from the center of the track, and a stake set for it. This is not much of a job, if two men go along the track carrying the tape line stretched from place to place, while a third man sets stakes for the posts. By laying a board against the two panel posts, it lines the place for the middle posts. A bracket, made the proper height from the ground with the projections on it to fit between the boards, making the spaces the correct width, is very handy when building a board fence. It makes a much better fence than when the spacing is done by guess, and saves measuring the spaces.

If board fence is built with the boards meeting on the same side of the post, a batten should be nailed over the joint from the ground to the top of the post.

For a permanent snow fence constructed with posts and boards, the posts may be set about fifteen feet four inches apart, and the ends of the boards can be nailed on opposite sides of each panel post. By this method there is a larger amount of the board available for nailing when putting them up again after being torn, or blown off. It also saves the labor of sawing off the ends of the boards to make them meet square on the post.

FENCE TABLES.

3. The following table will be useful to foremen, when estimating the amount of fencing material required to build a post and board, or wire fence:

TABLE SHOWING NUMBER OF POSTS REQUIRED TO BUILD ONE MILE OF FENCE.

DISTANCE BETWEEN POSTS.	NO. POSTS IN ¼ MILE.	NO. POSTS IN ½ MILE.	NO. POSTS IN 1 MILE.
8 feet.	116	331	661
12 "	111	221	441
16 "	83	166	331
20 "	67	133	265
32 "	42	83	166

TABLE SHOWING THE NUMBER OF BOARDS REQUIRED TO BUILD ONE-QUARTER MILE, ONE-HALF MILE, OR ONE MILE OF FENCE AT A GIVEN NUMBER PER PANEL.

NO. OF B'RDS. PER PANEL.	ONE-FOURTH MILE.	ONE-HALF MILE.	ONE MILE.
4 boards.	330	660	1320
5 "	412½	825	1650
6 "	495	990	1980
7 "	577½	1155	2310
8 "	660	1320	2640
9 "	742½	1485	2970
10 "	825	1650	3300

One sixteen-foot fence board contains eight square feet of lumber. If a lumber estimate is required, multiply the number of boards wanted by eight, and the result is the number of square feet.

EXAMPLE:—4 boards per panel for ¼ mile of track=330×8=2,640 sq. ft. of lumber.

WEIGHT OF NAILS.

55, 10 penny, common nails, weigh one pound.
45, 12 penny, common nails, weight one pound.
30, 10 penny, fence nails, weigh one pound.
28, 12 penny, fence nails, weigh one pound.

To ascertain the amount of nails wanted to build a given length of fence, multiply the number of boards

by 6, and divide the result by the number of nails to the pound.

EXAMPLE:—For ¼ mile board fence, 330 boards, 4 per panel; number of nails per board6; number of fence nails per pound 30: $330 \times 6 = 1980 \div 30 = 66$ lbs.

WEIGHT OF FENCE WIRE.

5. The average weight of the wire now used by railroads is very close to one pound per rod for one wire, or about 6⅜ per 100 feet in length. When making estimates for wire fence, about 10 pounds to the mile of fence may be added for tying, splicing, etc. The weight of staples varies according to the size used. Seventy staples to the pound is the size most commonly used in building railroad fence.

A DAY'S LABOR.

6. The average day's labor for one man at building post and board fence, where the boards meet on the post, six to a panel, and the work of setting the posts is included, is about eight to ten panels of fence complete. When the ends of the boards lap on opposite sides of the post, thirteen to fifteen panels can be constructed by one man in a day. Building a post and wire fence, posts one rod apart, and four strands of wire, a man can construct about fifteen panels in a day; but a great deal depends on the conditions under which the work is performed, the quality of material used, and the quality or general excellence of the work when finished. The results obtained from a man's labor depend, first, on his intelligence; next, on his willingness to work; and, lastly, on his physical endurance. These three requisites should always be considered by a foreman when employing men; and when possible he should always choose for his men those who possess all the qualities mentioned.

WOVEN WIRE FENCES.

7. During the last years the barbed wire fences are gradually being replaced by woven wire fences, particularly in the East and in populous districts. They

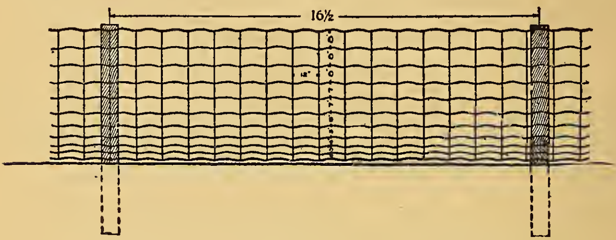


FIG. 30.

are generally made of steel wire of some meshed pattern, as shown in Fig. 30, and are fastened to the posts and the posts anchored in the ground, as shown in Fig. 31. The advantages of a woven wire fence are

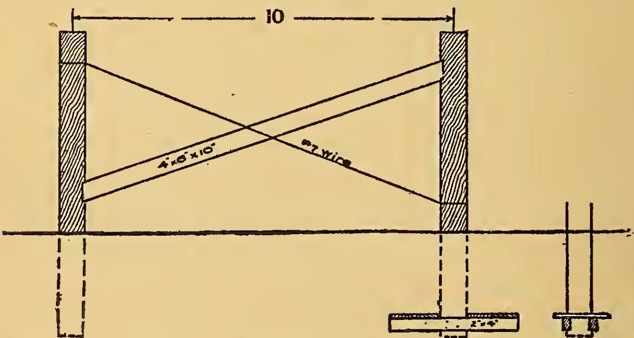


FIG. 31.

that they can be made so as to fence against almost any stock, besides there is less liability to accident than with the barbed wire fence, which is often injurious to stock.

CHAPTER XII.—GENERAL WINTER WORK.

GENERAL REPAIRS.

1. There are many kinds of track work which the section men should do during the winter months, all of which are important, and assist materially to lighten and advance the work of the following spring and summer.

In the early part of the winter, when the cold weather has contracted the rails, its effect on the rail joints, bolt, and splices should be noticed by the foreman, and all loose bolts should be tightened up, and broken or cracked splices should be replaced by good ones.

All open joints should be closed to the proper space, especially in the switches, to prevent the ends of the rails from becoming battered, and to save car wheels from breaking when passing over wide openings between the ends of the rails, as often happens in cold weather. All battered rails should be taken out of the track and replaced by good ones. When the number is so great that they cannot all be removed in a short time, good repair rails and splices should be distributed every mile or two along the section, so that when snow on the track, or bad weather interferes, broken rails or spikes can be replaced without any difficulty or unnecessary delay. As the winter advances, all good weather should be taken advantage of, and every spike above the rail flange, or leaning from it, should be

knocked down to place, and all of the track should be brought to a perfect gage.

Cleaning switches and yard tracks, and flanging out the main track after snow storms; shimming track, peeling the bark from ties, distributing ties for spring work, opening up ditches, and culverts, etc., all add to the section foreman's labor, and it requires a man of good judgment and energy to keep all of his work done properly at the right time and place.

If a foreman keeps the loose spikes knocked down to place, and a good gage on his track, he will be surprised at the splendid line which he can have on his track the following summer, and trains will ride over it without that disagreeable side motion of the cars which knocks the line and surface out of the track, and is so fatal to the comfort of passengers.

SHIMMING TRACK.

2. Shimming track is a very important kind of winter work on northern railroads, and should be done with a view to keeping straight track level, smooth and safe, and the proper elevation of the outer rails on curves.

Shims are placed under the track rails to raise up the low places to a smooth surface, and care should be taken to bring the rails to their proper place, where the track has heaved up. All shims should have holes bored through them for the track spikes. This can best be done by boring the holes through a block of straight grained hard wood, six inches wide by ten inches long, and splitting off the shims as thick as needed. On account of the difficulty of finding such wood in many parts of the country it would be best to have this work done in shops where old or broken timbers may be utilized for making shims, which can be sawed and bored to better advantage than out on the road.

The top surface of the track ties should be adzed off level, especially when there is a groove made by the rail. This is necessary to give the rails a solid foundation, preserve the correct surface, and prevent the shims from breaking. Shims should never be placed lengthways under the rails, because in that position they increase the height of the rail without widening the base. Section men cannot always see them, and they are liable to slip out of place, and by so doing weaken the support, and may cause a broken rail.

Where the shims used are over one inch in thickness, spikes seven or eight inches long should be used to secure the rails, and where thicker shims are used, old rail splices should be spiked on the ends of the ties and against the outside of the rails for braces. These braces should be spiked on every second, third or fourth tie, in proportion to the height of the shims.

To shim two or three inches high, plank of the proper thickness, sixteen feet long, should be cut in halves and spiked to the ties with boat spikes. For four-inch shims put a one inch shim on top of a three-inch plank or a four-inch plank, and for five-inch shim use a four-inch plank, with a one inch shim on top.

All high shimmed tracks should be watched closely, and thinner shims should be used to replace the thick ones as fast as the heaved track settles in the spring. Shims should not be removed from the track until all heaving has gone down, except where they are put under the rails to level up low joints or other spots which were left over in the fall of the year. When the rail which has shims under it is higher than the track either way from it by the thickness of the shims, you may remove them as the heaving has all gone out of

the ground. Many foremen have spoiled a nice piece of track by removing the shims and tamping the ties as soon as the frost was out to the bottom of the ties. All good shims, shim spikes and braces, should be put away in the tool house every spring, and saved for use another year. And any planks which were used for shims in the manner here mentioned, may be put in service during the summer on highways or private wagon crossings.

HEAVED BRIDGES AND CULVERTS.

3. Pile bridges and pile culverts need careful watching in the winter season, and whenever the section foreman finds them heaved up out of surface or line, the bridge carpenters should be promptly notified. In some bridges and culverts the piles which heave up have to be cut off, and that part of the bridge or the culvert must be lowered to correspond with the track on either side of it. Unlike the track in cuts, or on dumps, some piles which heave up in the winter do not settle back to place again when the frost goes out of the ground, and shims have to be put under the caps or stringers, to keep the bridges up to surface during the summer. The greatest danger is to be apprehended where the piles in a bridge heave up irregularly, as when only one or two piles heave in a bent, or when the piles heave up in opposite corners of two different bents. This often happens when the piles are driven in deep water, as the ice which freezes to them lifts them up and should, therefore, always be cut away by the trackmen before there is danger of its doing so.

REPORT AMOUNT OF SNOW.

4. Section foremen should ascertain the condition of the track in their charge immediately after every snow storm (or wind storm) which would be liable to

drift snow upon the track, and report to their roadmaster the depth and length of snow drifts in all the cuts on their sections. It is of the greatest importance that snow reports be sent promptly to the roadmaster by telegraph in order that the officers of the road may be able to make necessary preparations to clear the track.

SNOW ON SIDE TRACKS.

5. Section foremen should clear away the snow which has drifted upon side tracks as soon as possible after a storm, and the snow on switches and in frogs and guard rails, should be shoveled off and the track for the full length of the switch lead and moving rails should be swept clean. This work should never be delayed because all freight trains will need to do switching as soon as the road is open for traffic.

SNOW IN CUTS.

6. During the winter months when snow falls or is drifted into cuts to a depth of two or more feet, section foremen should take their men, just as soon as possible after the storm, and remove from the track sufficient snow at the ends of all drifts, to leave a clean flange and a clear face of snow, at least eighteen inches deep, at both the approach and run out ends of the drift. It is a notorious fact that a great many engines, when bucking snow, run off the track when coming out of, or running into a snow drift. This is generally caused by hard snow or ice in the flanges, as the engine, on being suddenly relieved of the resistance of the snow, easily mounts the rail on a hard flange way, and runs off the track.

FLANGING TRACK.

7. Whenever the track becomes full of snow in the winter it becomes necessary that the same should be

flanged out. On most roads they now have flanging machines for this purpose. These devices may be divided into two classes, such as are directly attached to the locomotive, and such as are built into a special car; the former class is obviously the best and most economical since it does not require a special train for the purpose of flanging a division, as the latter class requires. There are several patterns of flangers in use, but the Priest flanger has many points of advantage over others. It is operated by compressed air and is entirely under the control of the engineer. There is nothing about the flanger that can break, except the knives, if they strike a metallic obstruction, like a guard rail, and then they can be readily replaced in a few minutes; if the engineer is careful and raises the mechanism every time he approaches such an obstruction the knives will last until they wear out. When the flanger is used the only hand flanging the section men will have to do will be around frogs and switches and highway crossings, where the knives of the flangers have to be raised. On roads having no mechanical flangers the section men will have to do the flanging by hand practically the entire length of their section. They should then begin at the top of the heaviest grades first and then at places where it is difficult for engines to pull a train, like around heavy curves, or in cuts where track is heaved. This entails a great deal of work and is far more expensive and tedious than to equip the locomotives with improved flanging machines—they do the work more thorough and quickly, leaving a clear rail behind them for the following train or trains, and the section men can then put their time in to good advantage in having the switches and frogs clear of snow, and also do a good job flanging along the section at highway crossings, where the flanging

knives had to be raised. The "Priest" flanging machine has made an excellent record, having thoroughly flanged track at the head of heavy freight trains cutting through twelve inches of fairly hard snow, the trains making nearly schedule time.. When flanging track or shoveling snow in deep curve cuts the foreman should set out flags or post a look-out to avoid the danger of his men being run into by trains.

OPENING DITCHES AND CULVERTS.

8. On roads where snow lies on the ground during the winter months, section foremen should open up all ditches, culverts, and other waterways which pass along or under the track. Culverts, which are apt to be covered with snow in the winter, can easily be located when the thaw comes, if a long stake is driven close to the mouth of each culvert early in the fall of the year before any snow falls on the ground.

In cuts that are full of snow on each side of the track, leaving only room enough for trains to pass through, foremen should make a ditch in the snow when it begins to melt in the spring, about six feet from the rail on each side of the track, so that when the water begins to run it will not injure the track by running over it.

PROTECT YOUR MEN.

9. After the line becomes blockaded and before the snow-bucking gang arrives, section men should clean the snow off every other rail in long, deep cuts, which are certain to stick the snow plow. A look-out should be kept so that the men in the pits are not caught by the unexpected arrival of the train. But if the amount of snow in a cut is not sufficient to stall a snow plow it would be a waste of time to do this work. By cleaning the snow off alternate rails as mentioned,

if two engines, coupled together, are doing the "bucking," one engine will always have a clean rail under it and the resistance of the snow will not be great enough to stop the plow. no matter how long the cut may be.

SNOW WALLS.

10. If you have any snow fences for protection along the cuts on your section, watch them closely and whenever you find a fence which has been drifted full of snow or nearly so, build with blocks of snow, taken from the inside face of the drift, a wall four feet high along on the top of the highest part of the drift. As long as the weather remains cool a wall built of blocks of snow will give as good protection to a cut as the same amount of ordinary snow fence would. Make snow walls strong and thick and increase their height on the worst cuts in proportion to the force of men that can be spared to do the work, and use double lines of snow wall fifty feet apart when they will be beneficial.

SNOW FENCES.

11. On the majority of northern railroads the amount of snow which falls upon the ground during the winter months is not so great as to require the building of snow sheds, but to protect the cuts along the track from filling with snow, fences are built along the tops of the cuts at a sufficient distance from the track to catch the snow when it is drifted, and prevent it from being blown into the cuts and blocking the track. The efficiency of a snow fence as a protection against snow depends on its strength, durability, height, how far it is from the track and the manner in which it is arranged along the top of the cuts.

A snow fence, no matter how well made, or of what material, will rot and become useless in eight or ten years, at the latest. The yearly cost of repairing snow

fences, the first cost, and the interest of the money invested, should all be considered before putting up a snow fence on any railroad cut. And where the work of grading down a cut on each side of the track, so that it will not hold snow, can be done for an amount of money equal to the cost of the items above referred to, the grading of the cut should be done in preference to the building of a snow fence. In many sections of the northwest a cut which is only two or three feet higher than the track rails can be graded from the right-of-way limits down to a level with the bottom of the track ties, and the dirt wasted on the fills near at hand for less than it would cost to maintain a snow fence on the same cut.

Even when the cost of putting a cut into such a condition that it will not hold snow is somewhat greater than that of maintaining a good snow fence, the difference is in favor of the grading on account of the benefit the track derives from it. Except in high altitudes, on mountain railroads, snow fences are not needed at deep cuts, which from their top slope back into a valley within a short distance from the side of the track; nor are snow fences much good as a protection where the ground slopes with an incline off from the track unless the fence is close enough to carry the wind above the cut, or catch the snow before reaching the cut. Snow fence is not needed on cuts where heavy timber or underbrush grows close along each side of the track, as the only snow in such cuts falls directly upon the track. But where the ground is level for some distance from the track, or on a gently rolling prairie, cuts are liable to fill up with snow if not properly fenced. Snow fences should be set up at such a distance from the track that the edge of the snow drift forming inside of them will not reach within thirty feet of the track

when the fence is drifted full. A good rule is to set the fence about eleven or twelve feet from the track for each foot in height of fence. The height of snow fence should regulate its distance from the track. If a snow fence is set too far from the track for its height, the wind, after passing over the top of the fence, soon strikes the ground on the inside of the fence and gathers all the snow before it into the cut, and part of the snow which blows over the fence is also carried upon the track.

A snow fence is seldom set up on each side of the track unless the road is so situated as to be exposed to storms from both directions.

Storms from the northwest, north and northeast are the most prevalent throughout the northwest, and as a general rule the north sides of railroads running east and west and the west sides of roads running north and south need the most protection from snow. Where two snow fences are put up on one side of the track they should run parallel with each other, and there should be a space of at least 100 feet between them. Unless a very large quantity of snow is drifted the outside fence will hold it all.

Very good results have been attained by setting out the snow fence next to the track in the following manner. If the fence is of ordinary height, set it up seventy-five feet from the nearest track rail. Enough of the snow fence should run parallel with the track to reach the full length of the cut, no more. After this part of the fence is up, turn a wing on each end of it, approaching the track gradually until the extreme end of each wing extends 100 feet beyond the end of the cut, at a distance of about fifty or sixty feet from the track rail.

When a cut ends abruptly on the beginning of a

high fill, the wing on that end of the snow fence should be turned in toward the track before the end of the cut is reached, or at least soon enough to protect the cut from a quartering storm. A snow fence built parallel with the track and without a wing on the end of it, is of very little use when a storm blows nearly parallel with the track, as much of the snow on the inside of the fence is apt to be blown into the cut. New ties which are received for repair of track the following spring can be distributed and used advantageously to make a temporary snow fence on cuts where needed. The ties may be laid along in line with their ends lapping each other, about one foot slats or pieces of board can then be put across the ends of the ties where they lap and a new line of ties laid along on top of them until the snow fence is of the proper height.

CHAPTER XIII.—BUCKING SNOW.

GENERAL REMARKS.

1. Clearing the track of snow in the winter really belongs to the roadmaster's department, but as this book is intended to instruct young men who may fill that position at some time in the future, they cannot get too much information upon a subject which is of so much importance to railroad companies who are troubled with snow on their roads to a greater or less extent every winter.

No man is so well qualified to buck snow as he who has had some experience at it, and no man should be trusted with full charge of a snow plow outfit unless it be known that he understands the best methods to be employed in opening up the road for traffic after a blockade. The man in charge of a snow plow outfit should be informed of the exact condition of the road, the depth of snow, the length of drifts, and the location of the same, as nearly as possible, before starting on the road. He should have good, live engines, and willing engineers. The plow itself should, like the engine and engineer, be the best that can be procured and of a pattern that could throw snow out of a cut eight or ten feet deep. Small plows, fenders, or other makeshifts which are only good to clean the rails of light snow, or gouge a hole through a big cut, should be left at home, and not taken out to buck snow. When there is a large quantity of it to be moved, the extra time

and labor expended in shoveling and pulling such craft out of the snow would purchase a good plow in one trip over the road. Another engine and car, with a conductor, train crew and shoveling gang, should follow close behind the snow plow during the daytime, and should be coupled in behind the plow when running after dark. The second engine should be used as a helper in striking deep snow, and to pull out the plow engine whenever it is stuck fast in a snowdrift. All cars attached to the helper engine should be left behind on the clear track when both engines run together to buck a drift of snow. The pilot should be removed from the engine which is used for a helper, so that a close coupling can be made when both engines are used together. The less slack there is between two engines coupled together the less liability is there of the hind engine pushing the front engine off the track. This is most liable to happen on a curve track, or where hard snow is encountered. Never allow two engines to buck snow with a long car coupling between them, or with a caboose or other car between the engines, as either arrangement endangers the lives of the men on the train and often results in a wreck. There is no necessity for using two engines behind the snow plow to buck snow which one engine can as well throw out. If the snow is not too hard one good heavy engine and plow will clear the track of a snow drift three to five feet deep, and from five to eight hundred feet in length, at one run. However, with the improved rotary snow plow available, it is not likely that snow plowing with a plow on the front of a locomotive will be done to any great extent in the future, especially when cuts are deep and long, and snow is hard. But when the snow is soft, and not too deep on the track, the old way of getting rid of it is still apt to be practiced.

TWO LOCOMOTIVES.

2. Two good locomotives coupled together behind the plow, if managed properly, will remove any snow which it is advisable to buck. Snow drifts which are higher than the plow cannot be cleared from the track successfully without first shoveling the snow off the top of the drift, except when the drift is very short. Where the top of the snow drift is shoveled off, it should be opened wide enough to allow the plow to throw out of the cut the snow left in it. On roads where a flanger is used and made to pull behind an engine on a train, it should be sent with the snow plow helper, and used to clean out the snow left between the track rails by the snow plow. When the snow is reported hard those in charge of snow plow outfits should be very careful to have their engines and plow in as perfect condition as possible. They should run no risk; every snow drift should be examined before running into it, and each end should be shoveled out enough to leave a clean flangeway and a face that would let the plow enter under the snow and kept it down upon the rails. The tendency of hard snow is to lift the plow up over the top of the drift and throw the engine off the track. Whenever the ends of the drifts are not faced as before mentioned, there is always great danger when entering or leaving short, shallow drifts of hard snow, while on the contrary there is little or no danger in plowing soft, deep snow at the greatest speed the engine can make.

The engines with a snow plow outfit should always take on water and fuel to their full capacity at every point on the road where a supply can be obtained, no matter whether it is liable to be used or not. When it is at all probable that progress will be slow on account of hard or deep snow, a car loaded with coal

should be taken along by the helper engine. If there is plenty of snow the supply of water can easily be made in the engine tanks by commencing to shovel snow into them before they are more than half empty.

A PIECE OF STEAM HOSE.

3. Every snow plow engine, and helper engine should be supplied with a piece of steam hose which can be attached to the siphon cock and reach from it to the water hole in the back of the tank. With this hose an engine steaming well can quickly make a full tank of water from snow shoveled into the tank. It is also useful to thaw out the machinery or clean the track rails of ice.

LENGTH OF RUNS.

4. In plowing snow the length of runs and the speed of the engine should always be in proportion to the depth and length of the snow drifts. If the drifts are deep and long, and likely to stick the plow, a good long run should be taken on the clear track, so that the plow engine may acquire its greatest speed before striking the drift. A good engineer who has had some practice in bucking snow, will so handle his engine that very little shoveling by the men will be needed.

It is not advisable to start out on the road with a snow plow outfit during a heavy storm, but everything should be ready to make a start as soon as the storm is over. The snow plow should be attached to the best and heaviest engine in service on the division where it is used.

The man in charge of a snow plow outfit should use his best judgment and have his wits about him at all times, that he may not be caught on the road with a dead engine, or be wrecked and block the road for other trains. It is much better for the company's interests, and those of all others concerned, when all accidents

are avoided, even should it take much longer time to open up the road.

The engineer of the snow plow engine should sound the whistle frequently when approaching a cut, so that section men, if working there, would be warned in time to get out of the cut. When the snow plow is making repeated runs for a big snow drift, the signal to come ahead should never be given until all the snow shovelers have left the cut. It is very difficult for men to climb out of a cut where the snow is deep, and many accidents have occurred where approaching trains have failed to warn the men in time, or where the men have neglected to look out for the danger until it was too late. If the men with the snow plow are always on the alert, and careful and conscientious in the discharge of their duties, the safety of all concerned will be assured and the work will progress rapidly.

PREPARING DRIFTS.

5. When a snow drift is so long and deep that it may stick the snow plow twice, the better policy is to have the section men clean alternate rails for common snow plows. If rotary is used all snow more than ten feet above rails must be shoveled out.

All very hard snow should be broken up by the men and the crust thrown out before striking it with a snow plow. The shock felt when a snow plow strikes a hard drift is sometimes very great, and often damages the machinery, or knocks the plow from the track. The force of the concussion may be materially lessened by having the men clean a good flange way, and then shovel out of the face and top of the drift enough snow to make a gradual incline of about one foot to the rod. Besides reducing the force of the shock the above method of preparing a hard snow drift enables the snow plow to open a much greater distance at a run.

CHAPTER XIV.—LAYING OUT CURVES.

GEOMETRICAL PROPERTIES.

1. Curves are spoken of as being of a certain degree or radius. The radii of curves are proportional to the degree of curvature. The radii corresponding to any degree may be found approximately, by dividing 5,730 (the radius of a 1 degree curve) by the degree of curve.

Hence the radius of a 5 degree curve$=5730\div5=1146$.

This rule is very close for radii of not less than 500 feet.

The middle ordinate of a chord is the perpendicular distance from the middle of the chord to the curve; thus M N, Fig. 32, is the middle ordinate of the chord, C D.

The middle ordinate may be found, approximately, by dividing the square of the chord by eight times the radius. The error for a 50-foot chord on a 20-degree curve is only 1-32 of an inch.

The chord deflection of a 100-foot chord may be ascertained (exactly) by dividing 10,000 by the radius in feet. The tangent deflection is one-half the chord deflection.

RADII, ORDINATES AND DEFLECTIONS FOR 100 FEET CHORDS.

Deg. D.	Deg. M.	Rad. FT.	Mid. Ord. FT.	Mid. Ord. IN.	Tang. Deflec. FT.	Tang. Deflec. IN.	Cord. Defl. FT.	Cord. Defl. IN.	Deg. D.	Deg. M.	Rad FT.	Mid. Ord. FT.	Mid. Ord. IN.	Tang. Deflec. FT.	Tang. Deflec. IN.	Cord. Deflec FT.	Cord. Deflec IN
0	10	34377	0	0 7/16	0	1 3/4	0	3 1/2	7		819	1	6 5/16	6	1 1/4	12	2 1/2
	20	17189	0	0 7/8	0	3 1/2	0	7		10	800	1	6 3/4	6	3	12	6
	30	11459	0	1 5/16	0	5 1/4	0	10 1/2		20	782	1	7 3/16	6	4 3/4	12	9 1/2
	40	8594	0	1 3/4	0	7	1	2		30	765	1	7 5/8	6	6 1/2	13	1
	50	6875	0	2 3/16	0	8 3/4	1	5 7/16		40	748	1	8 1/16	6	8 1/4	13	4 7/16
1		5730	0	2 5/8	0	10 1/2	1	8 15/16		50	732	1	8 1/2	6	10	13	8
	10	4911	0	3 1/16	1	0 3/16	2	0 7/16	8		717	1	8 15/16	6	11 3/4	13	11 7/16
	20	4297	0	3 1/2	1	2	2	3 15/16		10	702	1	9 3/8	7	1 7/16	14	2 5/8
	30	3820	0	3 15/16	1	3 11/16	2	7 7/16		20	688	1	9 1[illegible]/16	7	3 3/16	14	6 3/8
	40	3438	0	4 3/8	1	5 7/16	2	10 7/8		30	675	1	10 1/4	7	4 15/16	14	9 7/8
	50	3125	0	4 13/16	1	7 3/16	3	2 3/8		40	662	1	10 11/16	7	6 1[illegible]/16	15	1 3/8
2		2865	0	5 1/4	1	8 15/16	3	5 7/8		50	649	1	11 1/8	7	8 7/16	15	4 13/16
	10	2645	0	5 11/16	1	10 11/16	3	9 3/8	9		637	1	11 9/16	7	10 1/8	15	8 5/16
	20	2456	0	6 1/8	2	0 7/16	4	0 7/8		10	62	2	0	7	11 7/8	15	11 13/16
	30	2292	0	6 9/16	2	2 3/16	4	4 3/8		20	615	2	0 7/16	8	1 5/8	16	3 1/4
	40	2149	0	7	2	3 15/16	4	7 7/8		30	604	2	0 7/8	8	3 3/8	16	6 3/4
	50	2022	0	7 7/16	2	5 11/16	4	11 5/16		40	593	2	1 5/16	8	5 1/8	16	10 1/4
3		1910	0	7 7/8	2	7 7/16	5	2 13/16		50	583	2	1 3/4	8	6 7/8	17	1 11/16
	10	1810	0	8 5/16	2	9 3/16	5	6 5/16	10		574	2	2 3/16	8	8 5/8	17	5 3/16
	20	1719	0	8 3/4	2	10 7/8	5	9 13/16		30	546	2	3 1/2	9	1 13/16	18	3 5/8
	30	1637	0	9 3/16	3	0 11/16	6	1 5/16	11		522	2	4 13/16	9	7	19	2
	40	1563	0	9 5/8	3	2 3/8	6	4 3/4		30	499	2	6 1/8	10	0 1/4	20	0 1/2
	50	1495	0	10 1/16	3	4 1/8	6	8 1/4	12		478	2	7 7/16	10	5 7/16	20	10 7/8
4		1433	0	10 1/2	3	5 7/8	6	11 3/4		30	459	2	8 3/4	10	10 5/8	21	9 1/4
	10	1375	0	10 7/8	3	7 5/8	7	3 1/4	13		442	2	10 1/16	11	3 7/8	22	7 11/16
	20	1322	0	11 5/16	3	9 3/8	7	6 3/4		30	425	2	11 3/8	11	9 1/16	23	6 1/8
	30	1274	0	11 13/16	3	11 1/8	7	10 1/4	14		410	3	0 11/16	12	2 1/4	24	4 1/2
	40	1228	1	0 3/16	4	0 7/8	8	1 3/4		30	369	3	2	12	7 7/16	25	2 7/8
	50	1186	1	0 11/16	4	2 5/8	8	5 3/16	15		383	3	3 5/16	13	0 5/8	26	1 1/4
5		1146	1	1 1/8	4	4 3/8	8	8 11/16		30	371	3	4 5/8	13	5 13/16	26	11 5/8
	10	1109	1	1 1/2	4	6 1/16	9	0 3/16	16		359	3	5 15/16	13	11	27	10
	20	1075	1	2	4	7 13/16	9	3 11/16		30	348	3	7 1/4	14	4 3/16	28	8 3/8
	30	1042	1	2 3/8	4	9 9/16	9	7 1/8	17		338	3	8 5/8	14	9 3/8	29	6 3/4
	40	1012	1	2 7/8	4	11 5/16	9	10 5/8	18		320	3	11 1/4	15	7 3/4	31	3 7/16
	50	983	1	3 1/4	5	1 1/16	10	2 3/16	19		303	4	1 7/8	16	6 1/16	33	0 1/8
6		955	1	3 11/16	5	2 15/16	10	5 5/8	20		288	4	4 1/2	17	4 3/8	34	8 3/4
	10	930	1	4 1/8	5	4 9/16	10	9 1/8	21		274	4	7 1/8	18	2 11/16	36	5 3/8
	20	905	1	4 9/16	5	6 5/16	11	0 9/16	22		262	4	9 3/4	19	1	38	2
	30	882	1	5	5	8	11	4	23		251	5	0 7/16	19	11 1/4	39	10 1/2
	40	860	1	5 7/16	5	9 3/4	11	7 1/2	24		240	5	3 1/16	20	9 1/2	41	7
	50	839	1	5 7/8	5	11 1/2	11	11	25		231	5	5 3/4	21	7 3/4	43	3 1/2

TO LAY OUT A CURVE BY THE EYE.

2. In Fig. 32 the line H C, subtends the angle formed by the tangent, A B, produced to H, with the chord B C, and is called the tangent deflection. The line I D, which subtends the angle formed by the chord B C, produced to I, with the chord C D, is called the chord deflection. The number of degrees in the angle, I C D, expresses the degree of curve. The tangent deflection is equal to one-half the chord deflection.

Table 3 has the radius, tangent deflection, chord

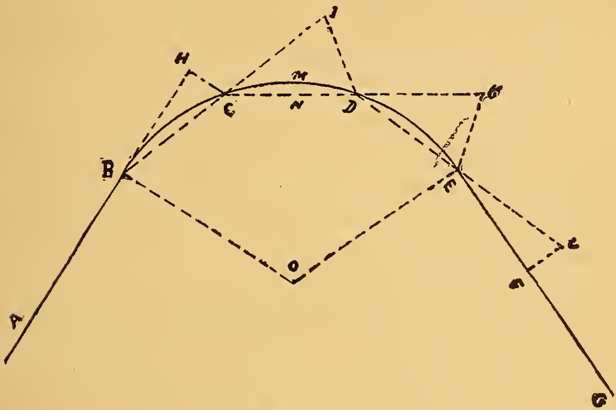


FIG. 32.

deflection and middle ordinates, calculated for chords of 100 feet for differences of 10 minutes. For a curve containing odd minutes, the parts can be readily calculated by simple proportion. Having these respective distances, any intelligent foreman can trace a curve on the ground, with tolerable accuracy, especially where the ground is favorable. Suppose it be required to lay out in this manner, a four-degree curve.

First, find from table 3, the tangent deflection, H C. corresponding to a four-degree curve, viz, 3 feet $5\frac{7}{8}$

inches, and also the chord deflection, I D, or K E, 6 feet $11\frac{3}{4}$ inches. Then from the starting point, B, and in line with A B, measure B H, equal to 100 feet, and mark the point H. Swing the tape around toward B C, keeping the end at B fixed, at the same time measure from the point H, the tangent deflection 3 feet $5\frac{7}{8}$ inches, and place a stake at C, for the first point on the curve. Then make C I, equal to 100 feet, putting a peg at I, in line with those at B and C. Swing the tape or chord around until I D is equal to the chord deflection, 6 feet $11\frac{3}{4}$ inches. Place a stake at D for the second point on the curve.

In the same manner continue the chord deflection until the end of the curve is reached at E.

In order to pass from the curve at E, into the next tangent, E G, make E L equal to 100 feet, and put in a peg at L in line with those at D and E. Swing the tape around until F L is equal to the tangent deflection. Then will a line, passing through E and F, be tangent to the curve at E.

If the last chord, D E, is less than 100 feet, its tangent deflection can be calculated by multiplying the square of the sub-chord by the tangent deflection of a 100-foot chord, and dividing by 1,000. Then throw off a tangent to the curve at D, lay off from it the calculated tangent deflection for the sub-chord, making D E of the given length. Lay the curve out and let the stakes form the center line of track.

TO FIND THE RADIUS OF A CURVE REQUIRED TO REACH ANY DESIRED OBJECT, THE POINT OF CURVE BEING KNOWN.

3. In Fig. 33, A B, represents a tangent, and starting at a point as A, it is required to reach the point C. From the starting point A, measure along the tangent to a point B, square across from C, then measure the

perpendicular distance, B. C. Then divide the square of the distance, A B, by twice B C and to the quotient add $\frac{1}{2}$ B C, the result will be the required radius. The line of the perpendicular can be obtained by placing the gage on the track, and sighting along it; or if A B is only a line of stakes, as the line of the frog produced, lay off on the ground the sides of a right angle triangle, 15, 20 and 25 feet are conventient lengths, always making 15 or 20, coincide with the given tangent. If the main line is curved, the measurements may be taken

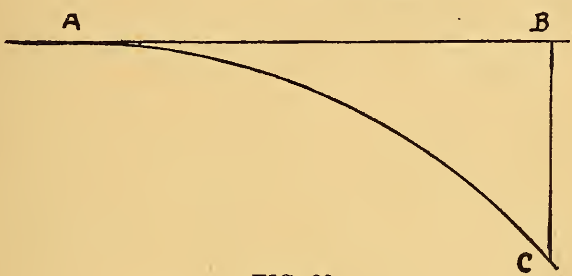


FIG. 33.

on the prolongation of the tangent through the starting point.

EXAMPLE:—Given A B =400 and B C, =162.4, to find radius. Radius =(400×400) ÷ (2×162.4)+(162.4 ÷ 2) =492.6 +81.2 =573.8, the radius of a 10 deg. curve.

If B C and the radius of the curve are given, A B is calculated as follows: From twice the radius subtract B C; multiply this difference by B C, and extract the square root.

EXAMPLE:—B C = 164.4 and the radius 573.8; A B = 573.8 ×2 = 1147.6, 1147.6—162.4 × 162.4 = 15996.48, the square root of which is 400—nearly.

METHOD OF LAYING A SPUR TRACK CURVE.

4. In Fig. 34 it is required to lay a permanent track to a warehouse at K, from main line, A D.

Range a tangent, E I, at the proper distance from,

and parallel to the warehouse. Then at a convenient point, as C, on the center line of main track, lay off the angle, D C E, equal to the angle of the frog used.

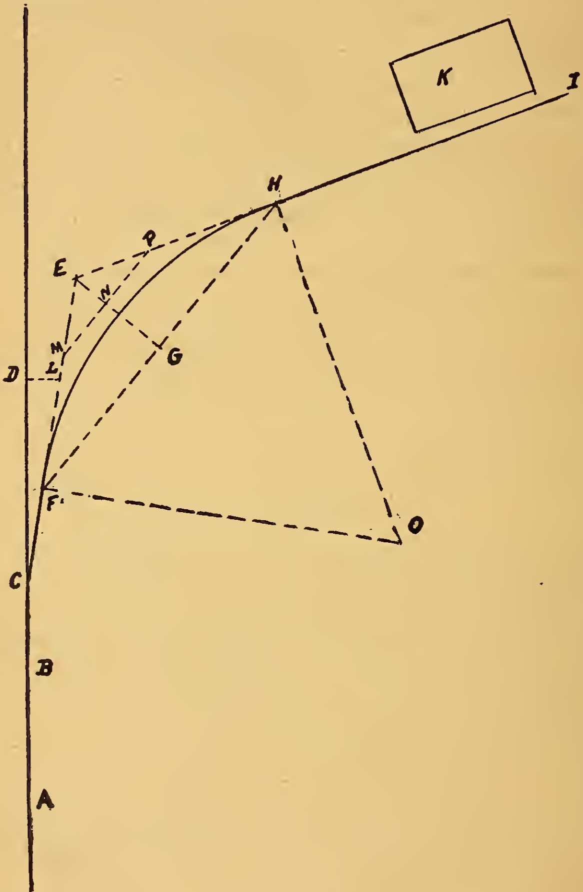


FIG. 34.

A simple way of doing this is to measure a convenient distance, C D, say 100 feet, along center line of main track, placing a peg at D. Divide this distance by the

frog number, and make the perpendicular, D L, equal to the quotient obtained. Produce the line from C through L until it intersects the tangent from the warehouse in E; mark this point. Take from turnout table No. 1, in column headed "Tangent," the distance opposite the number of frog used. Make C B equal to this distance, and B will be the heel of switch. Also make C F, the same distance, and F will be a point on center line of turnout, opposite the point of frog.

It now remains to join the straight lines, C E, and I E, with a curve. If it is desired to commence the curve at the point of frog, measure the distance, F E, and lay off an equal distance, E H, on the tangent E I. F and H will be, respectively, the beginning and end of curve. To find the radius to join these tangents, measure the distance F H, putting a peg at G, midway and on line between F and H. Measure E G. The radius required will be equal to F G multiplied by F E, and the product divided by E G. The curves can then be put in by the method given in paragraph 2, describing how to lay out a curve by the eye.

EXAMPLE:—F E measures 260, F G, 254 and E G, 57.61. Radius = 260 × 254 ÷ 57.61 = 1146.5, corresponding to a 5 deg. curve.

If a radius is assumed, the distances to measure down the tangents to set the beginning and end of curve must be calculated. From E, Fig. 34, measure any convenient equal distances, E M and E P. Measure M P, putting a point N midway and on line between them, and measure E N. The tangents of the curve will be equal to E N multiplied by the radius and the product divided by M N.

EXAMPLE:—M N = 80; radius 955; E N = 18. Tangents= 855 × 18 ÷ 80 =201.5.

DIFFERENCE IN LENGTH BETWEEN THE INNER AND OUTER RAILS OF A CURVE.

5. There are three different methods for finding this difference:

1st. The difference in length may be taken at 1 1-32 inches, per degree of curve, per 100 feet.

EXAMPLE:—To find the difference in length between the inner and outer rails on 600 ft. of 10 deg. curve. Here $10 \times 1\ 1\text{-}32 \times 6 = 5.124$ ft. = 5 ft. 1½ inches.

2d. Divide the distance from center to center of the rails (ordinarily 4 feet 11 inches equal 4.9167 feet) by the radius of the curve, and multiply the result by the length of the curve in feet.

EXAMPLE:—Taking the same example 600 ft. of 10 deg. curve, $4.9\ 67 \div 573.7 \times 600 = 5.142$ ft. = 5 ft. 1¾ inches.

3d. Multiply the excess for a whole circumference, by the total number of degrees in the curve, and divide the product by 360. The excess for a whole circumference, no matter what the degree of curve, is equal to twice the distance between rail centers multiplied by 3.1416.

Where the distance between rail centers is 4 feet 11 inches, the excess for a whole circle is 30.892 feet.

EXAMPLE:—Taking the same example 600 ft. of 10 deg. curve. $30.892 \times 600 \div 300 = 5.148$ ft. = 5 ft. 1¾ inches —.

For the easier curves that are laid to exact gage the first method is the simplest. On sharper curves, where the gage is widened, or for narrow gage lines, use the second method, or prepare a table by the third method.

"BROKEN" OR "STAGGERED" JOINTS ON CURVES.

6. Whenever it is required to lay "broken" joints on curves, and even joints on tangent, it is necessary to cut but one rail. Find the difference in length between the inner and outer rails of the curve. Cut the rail so that one piece will be as much longer than the

other piece, as the difference between the inner and outer rails of the curve. Lay the longer piece on the outside at the beginning of curve. Continue the joints thus broken until the other end of the curve is reached, where it will be necessary to lay the other piece of the rail that was cut to make the joints even again.

Short rails should not be used on main track when it is possible to avoid doing so. A better way to lay a curve with broken joints is to use the number of short rails (22, 24, 25 or 26 feet long) at each end of the curve, necessary to break joints. These short rails are usually furnished in any desired quantity with each order for rails.

When it is desired to continue "broken" joints through two or more curves with short tangents between them, it may be done by adding together the central angles of the curves turning to right, substracting therefrom, all angles of curves to left, and treating the difference thus obtained as one central angle of curvature.

When laying track on curves with even joints, use one 29½-foot rail per 100 feet for each 6 degrees of curvature, as explained in Chapter I., paragraph 17.

CHAPTER XV.—ELEVATION OF CURVES.

GENERAL REMARKS.

1. The elevation of curves has been the subject of more dispute among trackmen than any other question relating to their work. It was a bone of contention fifteen years ago, when one-half inch elevation per degree of curve was considered by many to be sufficient for the speed of trains then, and now, with faster trains and more elevation, the point is still in debate and probably will be for the next fifteen years. The rails on straight track are kept level so that the weight of trains may be borne equally by both rails. If one rail was lower than the other it would receive more than half the load, which would cause the ends of ties on that side to sink still lower in the roadbed and then, because resting on an incline, the track would be moved to the lower side and out of line by the swinging of trains. The same is true, of course, if the weight on one rail is greater than on the other; the line and surface of the track will soon show kinks and swings.

CENTRIFUGAL FORCE.

2. If a train was standing still on a curve the rails would have to be level in order that each might bear half the weight. But when the train begins to move some extra weight would be thrown on the outer rail by the centrifugal force, which develops with the speed of the train. This centrifugal force is the resistance offered by all moving bodies to anything which may be inter-

posed to change their course from a straight line, and may be illustrated by throwing a stone at a board set at an angle of say 45 degrees. If the stone misses the board it will move onward in a straight line until forced to the ground by the attraction of gravity. But if it strikes the board it is deflected from its course about 90 degrees and the dent made in the board shows in a way the amount of force offered by the stone in resisting the effort of the board to change its course that much. But on railroads the curves are made long and as easy as possible, so that the destructive force shown by the impact of the stone against the board may be considerably reduced by distributing it over several hundred feet of track.

CENTRIPETAL FORCE.

3. This of itself being insufficient, the outer rail of the curve is elevated so that the centripetal force set up thereby may counteract the remaining centrifugal force. The centripetal force in this case is simply the force of gravity, which tends to tip the leaning cars over toward the inside of the curve. Now, when the curve is elevated so that these two forces exactly balance each other, the weight of a moving train will be supported equally by the two rails. If the elevation of a curve is just right for a speed of forty miles per hour, it is evident that trains running sixty miles per hour will press laterally against the outer rail, and if this pressure be great it may throw the track out of line or spread the rails. With trains running only twenty miles per hour, the weight would be greatest on the lower rail, and while it would tend to depress the rail still more, and perhaps develop swings when the ballast is weak, it would not spread the track.

EFFECTS OF DEGREE OF CURVE ON ELEVATION.

4. Some claim that one inch per degree for a speed of sixty miles per hour is right for curves of three degrees or less, but for each additional degree the elevation should not exceed $\frac{3}{4}$ inch.

Others start with one inch of the first degree and gradually reduce the elevation per degree to $\frac{1}{2}$ inch or even less as the curvature increases, under the impression that elevation should not exceed 5 or 6 inches on any curve. But this is an error, for the centrifugal force is developed in exact proportion to the degree of the curve. If a one-degree curve requires, say, 1 inch elevation, a six-degree curve will require 6 inches for the same rate of speed, because the train is deflected from a straight line six times as much on a six-degree curve as it is on a one-degree curve, and as the centrifugal force develops in proportion to the degree of curve, the centripetal force or elevation necessary to balance the weight should rise in proportion. Hence, for a given speed the elevation of curves should be increased according to the degree of curve.

EFFECT OF SPEED ON ELEVATION.

5. The elevation necessary on curves, however, depends more on the speed than on the degree of curve. For instance, if a four-degree curve requires 4-inch elevation for a speed of fifty miles per hour, for a speed of twenty-five miles per hour it would require not 2 inches but only 1 inch to balance the weight of trains. This may be illustrated by Fig. 35.

A weight B is suspended from a rigid support S by a cord A. By giving the weight a circular motion it will describe a circle c around a center e, and the angle of the cord A B will show what elevation would be required if the circle c was a track in order to distribute

the weight of B if it were a car equally on each rail at a given speed; that is, the level of the rails should be at right angles to the line S B to give the curve the proper elevation for the rate of speed at which the weight B moves around the circle. Suppose that circle c represents a four-degree curve and the inner circle d, with but half the radius of c, represents an eight-degree curve. Now, if the weight B moves around the outer, or four-degree, curve, in say four seconds, it will re-

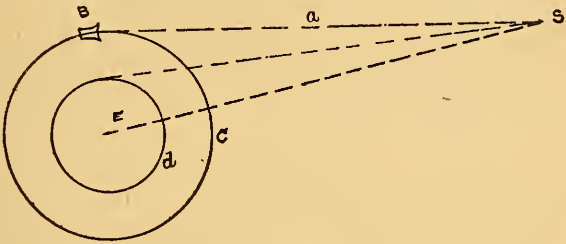


FIG. 35.

volve in continually decreased circles, but always in the same period of time, and will move around inner circle, or the eight-degree curve, in four seconds also. But the inner circle being but one-half the circumference of the outer, it follows that the speed of the weight is reduced one-half. The position of the dotted line shows that the angle of the cord has been reduced one-half also, and this indicates that the elevation of curve d should be one-half that of curve c. Now suppose weight B is a car traveling around four-degree curve c at fifty miles per hour, and the angle of the cord S B shows that an elevation of 4 inches is necessary to bring the level of the rails to a right angle with the cord, then when the car moves around eight-degree curve d it is going at the rate of twenty-five miles per hour, and the elevation necessary, as shown by dotted

line, is half that of outer curve, or 2 inches. Therefore, if an eight-degree curve should be elevated 2 inches for a speed of twenty-five miles per hour, a four-degree curve should be elevated only 1 inch for the same speed, as previously stated.

It requires perhaps more than a passing thought to understand the two elements that must be considered in calculating elevation. One is increase of speed and the other increase of curvature. In one case elevation should increase in exact proportion to the increase of curvature where the rate of speed is the same. In the other, if the speed is increased say two times the elevation should be increased four times where the curvature is the same. This explains the reason for giving such light elevation in yards and other places where the speed does not exceed twenty-five miles per hour in proportion to the elevation given main tracks when the speed is fifty miles per hour. In fact, some roads, while giving liberal elevation on main line curves, allow little or none in yards.

HOW TO CALCULATE THE ELEVATION.

6. While the theory of elevation is easily understood and practice will teach the amount needed in any given case, yet it seems very difficult to find a rule having a scientific basis which may be applied to all conditions of track work.

The correct rule deduced from Mechanics is

$$E = \frac{v^2 g}{32.16 R}$$

the result being in feet or fractions of a foot. The terms employed, v^2 means the square of the velocity in feet per second. This should be multiplied by g, the gauge, which in this case is the distance between points supporting the wheel, or from the cen-

ter of one rail head to the center of the other, say 5 feet, instead of $4.8\frac{1}{2}$ feet, and the result divided by the product of 32.16, which represents the intensity or force of gravity, multiplied by R, or radius of the curve in feet, the result will be the elevation expressed in feet or fractions of a foot. That the rule may be understood by all, the following examples are made as plain as possible. What elevation should be given a four-degree curve for a speed of sixty miles per hour? In this case the velocity is 88 feet per second and the radius of this curve 1433 feet; therefore, 88 is multiplied by 88, and the result by the gauge 5 feet=38720; this is divided by 32.16 multiplied by radius 1433=46085

$$\frac{38720}{46085} \text{ ft.} = 10 \text{ inches.}$$

What elevation should be given a four-degree curve for a speed of thirty miles per hour, velocity 44 feet per second?

$$\frac{44 \times 44 \times 5 = 9680}{32.16 \times 1433 = 46085} \text{ ft.} = 2\tfrac{1}{2} \text{ inches.}$$

In this example the result follows closely the practice of trackmen who give $\frac{1}{2}$ inch per degree for a speed of thirty miles per hour, but in the former example the result 10 inches for a four-degree curve for a speed of sixty miles per hour is more than twice the amount of elevation usually given. This may be accounted for by the fact that the rule aims only to place the weight of trains equally on each rail, and it is correct in this respect, and if all trains passing over this curve ran 60 miles per hour, 10 inches would be the proper elevation. In practice, however, the section foreman adjusts the elevation for the average speed of the fast and slow trains because where one train makes sixty miles per hour and requires an elevation of 10 inches, there are several whose speed does not exceed thirty

miles per hour and the elevation needed only 2½ inches. This is done because 2½ inches would result in the fast train spreading the track or being derailed, while 10 inches would throw so much of the weight of the slow train on the inner rail that it would cut deeply into the ties and soon develop sags and low joints. Then, again, the foreman relies on the resistance to centrifugal force offered by the holding power of the wheel flanges of fast trains, and no allowance is made for this in the rule given. Hence the conflicting requirements of the traffic may be adjusted by reducing the elevation necessary for the fast train to a point where the pressure against the outer rail of the curve will be increased, but still not sufficient to spread the rails, and by doing so the elevation, while still too great for the slow trains, is not enough to cause any particular injury to the line or surface of the lower rail. In this case, if the number of fast and slow trains using the four-degree curve were about equal 6-inch elevation would probably prove satisfactory. But if the slow trains predominated 5 or perhaps 4 inches would be sufficient.

USE RULE WITH COMMON SENSE.

7. While the rule referred to is no doubt correct, its meaning is liable to be misunderstood and the elevation called for is more than is really intended should be given. For instance, find elevation for a speed of 114 miles per hour on a six-degree curve, velocity 167.2 feet per second, radius 955 feet.

$$\frac{167.2 \times 167.2 \times 5 = 139779}{32.16 \times 955 = 29712} = 4 \text{ ft. } 8\tfrac{1}{2} \text{ inches.}$$

Elevation of 4 feet 8½ inches would bring the elevation plane of the outer rail exactly 45 degrees over the lower rail. To illustrate this refer to Fig. 36.

The elevation called for of 4 feet 8½ inches is from

B to D, and in elevating the rail B according to the rule it would meet the line of the plane D A at the point c or at an angle of about 45 degrees. Accordingly the actual elevation is always less than the calculations appear to call for, and this variation increases as the elevation becomes greater. The rule, though scientific and correct, cannot be applied in actual practice, because all trains do not travel at the same rate of speed, and whatever rule is substituted must be based on the average speed of trains and the number in each class of service.

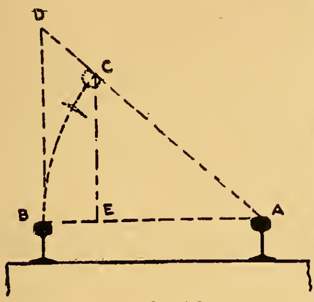


FIG. 36.

OTHER RULES.

8. Of rules for the elevation of curves having no scientific basis, but founded on experience, there seems to be no end. Nearly every engineer and roadmaster has his own pet theory, and so there can be no harm done to add another. If a road have, say, two trains whose speed is fifty miles per hour, four with a speed of forty, and six or eight with a speed of twenty to twenty-five miles per hour, it is believed that 1 inch per degree of curve will be found suitable, that is, the pressure by the fast train against the outer rail of a curve will not be sufficient to spread the rail or throw the track out of line. The elevation will be about right for the forty-mile trains, and while it may be excessive for the slow trains, yet they will do no particular damage to the track and will have a tendency to prevent the track being moved permanently outward by the fast trains. If it be conceded that 1 inch per degree of

curve be sufficient where the fast trains make fifty miles per hour, then the following rule would be found satisfactory:

$$E = \frac{v\,d}{50}$$

In this e elevation in inches, v velocity or speed in miles per hour, d the degree of curve, and 50 the basis for 1 inch elevation. Example: Find elevation required for six-degree curve at sixty miles per hour:

$$\frac{60 \times 6 = 360}{50 = 50} = 7\ 1\text{-}5 \text{ inches.}$$

Find elevation necessary for ten-degree curve at ten miles per hour:

$$\frac{10 \times 10 = 100}{50 = 50} = 2 \text{ inches.}$$

But if 1 inch per degree seems too much for a maximum speed of fifty miles per hour, the number may be changed to sixty, or if it is thought 1 inch is insufficient elevation for that speed, forty-five may be substituted. If there are any reasons for decreasing the number from fifty to forty-five it may be found on a road using very soft ties where the pressure of fast trains on curves may cause the rail to push the spikes outward, thus spreading the track on account of insufficient elevation. Or the number may be increased to sixty if tie plates are used. As tie plates offer two to four times the resisting power of a single spike, curves on which the plates are used may have less elevation without danger of track spreading than if no plates were used. Still very little will be gained by changing the number either way, and experience will show that fifty is very near correct on most roads.

CURVING RAILS.

9. Bend or curve the rail through its entire length until the middle ordinate of the rail equals as many

quarter inches as there are degrees in the curve for which you are preparing it.. To ascertain this, stretch a string between the extreme points of the rail on the gage side and measure the distance from the center of the string to the gage side of the rail at its center. For foremen who have not had much practice in curving rails it is best to also measure the distance from the string to the rail at the quarters, seven and one-half feet from the end of a 30-foot rail, and this distance should be three-quarters of what it is at the center of the rail. By measurements taken at the quarters it is generally easy to detect a kink in the rail, which should always be taken out. Rails which have a true curve will hold their place in the track ready for spik- with the bar. The more accurate the curve of rails, the less lining of track will be needed afterward.

The best tool for curving steel rails is the Roller Rail Bender. After the screw has been adjusted to the proper curve all that is necessary is to keep the walking beam lever turning and the bending machine will roll around the full length of rail, curving it uniformly and correctly; the bender need not be adjusted again until there is a change in the curvature. This tool is made now with a horse power attachment, which is especially desirable where great quantities of rails have to be curved.

MIDDLE ORDINATES FOR CURVING RAILS.

DEG. OF CURVE.	LENGTH OF RAILS.					
	30 ft.	28 ft.	26 ft.	24 ft.	22 ft.	20 ft.
	INS.	INS.	INS.	INS.	INS.	INS.
1	$0\frac{1}{4}$	$0\frac{3}{16}$	$0\frac{3}{16}$	$0\frac{3}{16}$	$0\frac{1}{8}$	$0\frac{1}{8}$
2	$0\frac{1}{2}$	$0\frac{7}{16}$	$0\frac{3}{8}$	$0\frac{5}{16}$	$0\frac{1}{4}$	$0\frac{3}{16}$
3	$0\frac{11}{16}$	$0\frac{5}{8}$	$0\frac{9}{16}$	$0\frac{7}{16}$	$0\frac{3}{8}$	$0\frac{5}{16}$
4	$0\frac{15}{16}$	$0\frac{13}{16}$	$0\frac{11}{16}$	$0\frac{5}{8}$	$0\frac{1}{2}$	$0\frac{7}{16}$
5	$1\frac{3}{16}$	$1\frac{1}{16}$	$0\frac{7}{8}$	$0\frac{3}{4}$	$0\frac{5}{8}$	$0\frac{9}{16}$
6	$1\frac{7}{16}$	$1\frac{1}{4}$	$1\frac{1}{16}$	$0\frac{7}{8}$	$0\frac{3}{4}$	$0\frac{5}{8}$
7	$1\frac{5}{8}$	$1\frac{7}{16}$	$1\frac{1}{4}$	$1\frac{1}{16}$	$0\frac{7}{8}$	$0\frac{3}{4}$
8	$1\frac{7}{8}$	$1\frac{5}{8}$	$1\frac{7}{16}$	$1\frac{3}{16}$	1	$0\frac{7}{8}$
9	$2\frac{1}{8}$	$1\frac{7}{8}$	$1\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{1}{8}$	$0\frac{15}{16}$
10	$2\frac{3}{8}$	$2\frac{1}{16}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{16}$
11	$2\frac{5}{8}$	$2\frac{1}{4}$	$1\frac{15}{16}$	$1\frac{11}{16}$	$1\frac{3}{8}$	$1\frac{1}{8}$
12	$2\frac{13}{16}$	$2\frac{1}{2}$	$2\frac{1}{8}$	$1\frac{13}{16}$	$1\frac{9}{16}$	$1\frac{1}{4}$
13	$3\frac{1}{16}$	$2\frac{11}{16}$	$2\frac{5}{16}$	$1\frac{15}{16}$	$1\frac{5}{8}$	$1\frac{3}{8}$
14	$3\frac{5}{16}$	$2\frac{7}{8}$	$2\frac{1}{2}$	$2\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{1}{2}$
15	$3\frac{9}{16}$	$3\frac{1}{16}$	$2\frac{11}{16}$	$2\frac{1}{4}$	$1\frac{15}{16}$	$1\frac{9}{16}$
16	$3\frac{3}{4}$	$3\frac{1}{4}$	$2\frac{13}{16}$	$2\frac{3}{8}$	$2\frac{1}{16}$	$1\frac{11}{16}$
17	4	$3\frac{1}{2}$	3	$2\frac{9}{16}$	$2\frac{3}{16}$	$1\frac{3}{4}$
18	$4\frac{3}{16}$	$3\frac{11}{16}$	$3\frac{3}{16}$	$2\frac{11}{16}$	$2\frac{5}{16}$	$1\frac{7}{8}$
19	$4\frac{7}{16}$	$3\frac{7}{8}$	$3\frac{3}{8}$	$2\frac{7}{8}$	$2\frac{7}{16}$	2
20	$4\frac{11}{16}$	$4\frac{1}{8}$	$3\frac{9}{16}$	3	$2\frac{9}{16}$	$2\frac{1}{8}$

PRINTED INFORMATION FOR FOREMEN.

10. On all curves it would be a good policy to have a plainly painted sign showing the degree of the curve. For the sake of economy the information could be given on a board secured to a telegraph pole near the curve. There could also be a rule on the time card calling the attention of the employes, most interested, to the subject. There is no reason why a foreman placed in charge of a piece of track should not receive all the information relative thereto that it is possible for the railroad company to give him, instead of having to find it out for himself as best he can. Printed information from the Engineering Department should supplement the track foreman's other instructions and in most cases it would materially assist in bettering the condition of the road, and bring more uniformity

into the work. If every section foreman was provided with a little book giving location, degree and amount of elevation of the outer rail on the curves on his section, together with location, size and number of all culverts and bridges, and distance from stations, also amount of snow fence on cuts, and kind and quantity of rails laid, etc., it would be placing the information where it would be of the most practical value to the railroad company.

CHAPTER XVI.—LINING CURVES.

ONE METHOD OF LINING.

1. Select any part of a curve track which seems to be in the best line for a distance of at least 60 feet, but do not begin at the point of a curve unless you

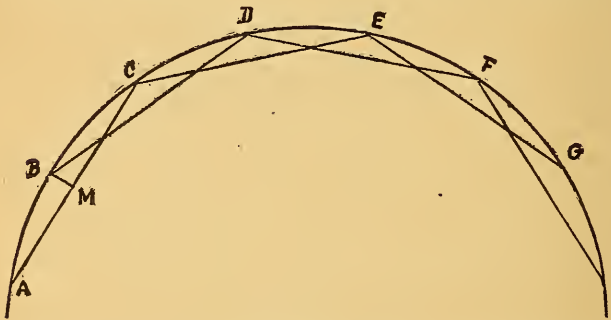


FIG. 37.

The letters A, B, C to G are track centers of a curve 30 feet apart; A C is a 60-foot line with which to ascertain the middle ordinate; B M shows where the measurements should be taken to find the middle ordinate.

know positively that the curve turns off from the straight track without leaving a swing in the line.

Set two stakes accurately in the center of the track, 60 feet apart, and one in the center of the track at the middle of the 60 feet. These three points are shown in Fig. 37 by the letters A, B and C. Now stretch a cord tight from A to C, and measure from the center of the cord indicated by M to the center stake, B. The result should be your guide as a middle ordinate for the balance of the curve in either direction from where

you commence work. We will suppose this middle ordinate to be four inches. You next move the cord 30 feet ahead in the direction in which you wish to line, stopping at B with the end you had first at A, and holding the end of cord which was at C in your hand until its center is directly opposite and distant just four inches from the track center, at C. You may then set track center D at the end of the cord which you hold in your hand. This process may be carried on until you have set track centers for the whole curve.

Every stake set for a track center should be driven into the ground, with its inside face or edge touching the cord, and this side of the stakes should be a straight edge if possible, so as to have a uniform center throughout the curve and along the inside face of all the stakes. This will obviate the necessity for using a tack to make an accurate center on the stakes.

After you have set the track centers for the whole curve, procure a gage which is square and true, and mark on the gage, with some sharp instrument, the correct center between track rails or middle of the gage. Place this gage on the track between the rails and over the track center where you wish to begin lining the rails to place. Then have your men move the track with their lining bars until the center, as marked on the gage, comes directly over the track center on the stakes. Move the track in this manner at every point where you have set a track center stake, and then go back over it again, taking out any kinks or other defects left in the line, and you will have a splendid and a true curve line on your track, as good as if a civil engineer had set your track centers with an instrument.

Care should be taken not to make any mistakes in measuring the middle ordinates, or in setting the track

centers. It will pay to take your time and do the job well, because if properly done (like well-surfaced track) it will only need to be retouched in spots ever after.

By commencing at a rail joint, this method of lining a curve may also be applied to the gage side of the rails, and any defects in the track line can be taken out by moving the rails to place as you go, but the work will not be as accurate or as reliable as by the process first given.

EFFECT OF LOCOMOTIVE AND CAR WHEELS ON CURVE TRACK.

2. Car wheels which are badly worn on the tread, or close to the flanges, or which have the flanges worn sharp, are very unsafe when passing over switches if there is the slightest lip on the rails. They are dangerous also on battered rails, or going around sharp curves, where they are liable to climb the rails and leave the track. Wheels of the kind mentioned have a tendency to hug the rail on their side of the track, and as a consequence make a considerable wear along the gage side of the ball of the rails. They also wear spots along the top surface of the outer rail on curves, because the circumference of the wheel being the same or worn smaller at the flange than at the outside, the wheel must slip a certain amount in proportion to the degree of curvature, in order to travel as fast as the wheel on the inside rail. When the drive wheels of an engine are allowed to run too long without being turned off, the groove worn in the tire often causes considerable damage to track before the cause is known. Badly worn drive wheels break the frog points when passing over switches, and as a general rule the most of the wear on the rails on curve track is chargeable to the same source.

IMPROPER ELEVATION.

3. On curve track where there is not enough elevation or the gage of track is tight, the car wheels wear off the gage side of the outer rail, by the wheel flanges crowding against it, and this causes the track to spread and become unsafe. If the elevation of the outside rail of a curve is excessive, the rails will wear most from the top surface downward and on the inside rail of curve. It also forces the inside rail below the proper surface.

It does not make the track any safer for trains and lessens the number of freight cars that an engine can haul over them. Especially is this the case when the elevation is excessive on sharp curves at terminal stations where trains run very slow.

LIABILITY OF DERAILMENT.

4. The liability of accident to trains such as the derailment of locomotives or cars, is much greater on a curve track than on a straight track, and a large percentage of the accidents which do happen is chargeable to the defects in the rolling stock as well as to the defects in the track itself. Heavily loaded freight cars often leave the track owing to the failure of a truck to adjust itself to the curve of the track, caused, perhaps, by a defective curve roller, and the greater part of the load resting upon one side of the truck.

REDUCED SPEED.

5. Curves of ten degrees or more are not common on the main line of standard gage railroads. When they do occur the speed of trains should be reduced in proportion as the degree of curve increases.

CARE OF CURVES.

6. The rails on curves could be made to wear much longer if those which showed signs of wear were trans-

ferred to the opposite side of track before they become badly worn. A depression of three-fourths of an inch in the surface of track on the outside rails, or a slight kink in a rail on a curve, or a joint out of line or gage, will throw every car in a train heavily to the opposite side of the track. For this reason track foremen should keep curve track in the best condition possible.

DEFECTIVE LINING.

7. Some foremen have a very bad habit of always lining the curves out. This should not be done. The tendency of engines and cars is to knock parts of the curves towards the outside at the weakest points. If the foreman will line towards the inside of the curve any points or rails which project beyond the true line of curve, there will not be any necessity of increasing the curvature by lining so much towards the outside.

A GOOD CURVE.

8. A curved track is put up properly when the engine and all the cars in a train run smoothly onto the point of a curve from the straight track without any shock or jar that would indicate there was a change in the line or surface of the track. All the cars in a train should run around the curve rail, and not change this position perceptibly until the straight track is reached again at the opposite end of the curve. Above all things, foremen should keep the surface of a curve track as smooth as possible. In this more than anything else lies the secret of having a good riding track.

DANGEROUS CARS ON CURVES.

9. It is both a foolhardy and dangerous policy to allow the cars from any road with a 4-foot 9-inch gage to run on a standard gage road unless the flanges of all wheels have the same "clearance" room between them and the rails as is allowed for the standard gage wheels.

The Interstate Commerce Commission reports for 1898 show 387 railroads, with a mileage of 28,939 miles of 4-foot 9-inch gage, while of the standard gage there are 1,030 roads operating 114,148 miles, which shows that with all our boasted progress there is yet nearly one-fifth of the railroad mileage of the country which does not conform to the standard gage, although the freight cars of these roads are inter-changeable.

It is a notorious fact that the cars of a railroad with a 4-foot 9-inch gage are the ones which are oftenest derailed when running on standard gage track, both on the main track and at switches, and on curves, and when not wrecked or derailed they are continually damaging the standard gage track and spreading the rails out of proper line and gage. The heavy pressure of flange against the rail soon makes those flanges very sharp and dangerous, peeling and wearing away the inner side of the track rails and always ready to climb the outer rail on curves; they are derailed by the slightest lip on a stub switch, and often run foul of a frog point.

These wheels have to be changed so often that it adds another large item to the cost of car repairs, and if the whole of the damage to track and other defects that are chargeable to this ruinous system were summed up and kept account of, we would have an exhibition of one of the most dangerous and expensive methods of operating railroads.

How often has one of these wide gage trucks jumped the track and wrecked a train on some sharp curve without leaving a clew for those who come to investigate the cause of the accident? Probably the track will be torn up and everything in confusion and some person will say that the trouble was caused by spreading of the rails or an improper adjustment of

the elevation of the outer rail on the curve or something else just as far from the truth.

CURVE EASEMENTS.

10. The length of run-off or easement at end of curves is another question for which there is no fixed rule. Some years ago the length of run-off was variously calculated at from 40 to 60 feet per inch elevation of curve. Then the curve was of uniform degree from point of curve at one end to point of tangent at the other end of curve, and the run-off was on straight track, and it must be acknowledged that some roads still adhere to this practice. But it is wrong in principle because it violates the rule that rails on straight track must be level. According to this plan a curve having 6-inch elevation would require a run-off about 300 feet long and, of course, the portion near the curve having from 3 to 6 inches elevation, could not be kept in line because of excessive weight on lower rail; and as the train approached the curve the weight on the lower rail gradually increased until the point of curve was reached, when it suddenly lurched toward the other rail. It is impossible to avoid this swing at the point of curve without compounding the end of curve, because even if all the weight of the train was concentrated on and balanced over the lower rail the sudden transition from tangent to curve would still cause the weight to swing toward the outer rail and the higher the degree of curve the greater and more sudden would be the shock. If a plumb line be suspended from the roof of a car, so that the weight hangs over the center line of track, the weight will show the variation between center of gravity and center of track, as is shown in Fig. 38 in ground plan.

It will be noticed that the weight leaves the center line of track at end of run-off and gradually gets

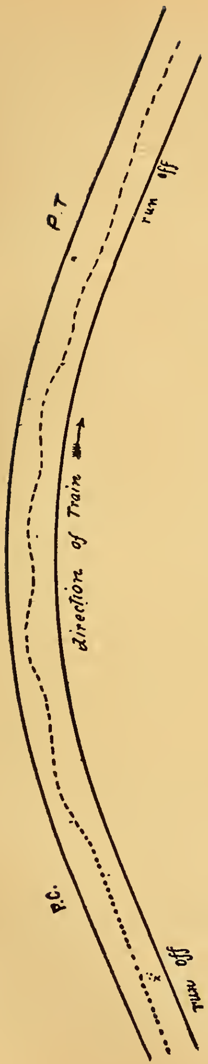


FIG. 38.

farther away until P C is reached, when it again moves toward and crosses center of track, until jerked back by the swing of the car and again thrown toward inner rail, and then swings from side to side until finally it rests over center of track, where it remains until P T is reached, when the centrifugal force, being lost, the weight swings toward lower rail on the run-off. The order and succession of these swings would, of course, be reversed by a train going in the opposite direction. This variation of weight from center line of track make it hard to keep the track at ends of curve in surface and line, and this led many roads to adopt the plan of compounding the point of curves. By this system, the elevation and curve go together—that is, a four-degree curve, for instance, instead of stopping abruptly, is changed near the end to a three-degree for a certain distance; then this to a two-degree, and finally to a one-degree, which is then graduated

to connect with the straight track. In this way the elevation on the run-off is balanced by the centrifugal force of the car moving around the curve, consequently the center of weight will always follow the center of track and there will be no swings on the curve. Now as to the length of run-off (by which is meant the easement between point of tangent and point of full curve) it may be said that while the old plan of making the run-off on straight track requires extending it out quite a distance, depending upon the speed of trains, by the easement plan it may be made much shorter. If a straight run-off from a curve having 6-inch elevation was, say 130 feet long, a car moving 60 miles per hour would have its center of weight which may be considered as being 6 feet above the level of the rails thrown inside the center of track, about 8 inches in one and one-half seconds; then after striking the curve the center of weight would be swung outward over a foot in a little more than one-half second, which would make a very perceptible swing. With the belief that longer run-offs would help the matter some were extended 50 feet per inch elevation. But with the easement plan, there being no swing, it is unnecessary to extend the run-off to such great distances. As the centrifugal and centripetal forces will always balance each other if the curvature be graduated in proportion to the elevation the run-off could be safely shortened to a considerable extent. If the easement be calculated at 50 feet for the first inch of elevation, 40 feet for the second inch, and 30 feet for each succeeding inch of elevation it is probable that the length of run-off would prove satisfactory for a maximum speed of 60 miles per hour. The elevation and curvature should increase evenly and at uniform distances from one end of the easement to the other. To change an ordinary curve without increasing the de-

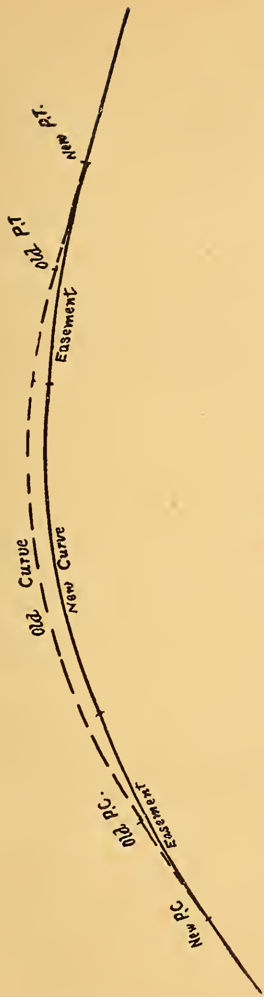


FIG. 39.

gree to one with easement at each end it is necessary to throw the track in a certain distance, and this depends on the length of run-off or easement desired at each end. Begin by driving stakes 50 feet apart at the outer ends of ties around the curve; then, if, for instance, the curve be a 2-degree curve, throw the track in uniformly all around the curve, so that the ties will be 5 inches away from the stakes. Now one-half the run-off may be lined inside the original point of curve and one-half outside or extended that much on the former tangent. If there is considerable expansion at the joints curves of 3 degrees or less may be thrown in without cutting rails, but if not it is best to get short rails and make the change before moving the track. This shortening of the curve by throwing the track in equals for each foot the

track is moved about one-fifth of an inch for each degree of curve per hundred feet in length. This applies to both rails. For instance, a five-degree curve 500 feet long is to be changed. Track must be moved $12\frac{1}{2}$ inches inward and will be 20 inches times 5 degrees times 5 (hundred feet) equals 5 inches shorter than old line. If the track was moved 6 inches it would be half that amount for curve of equal length. When sharp curves are to be changed it is best to have an engineer set stakes, especially if the foreman in charge of the section does not clearly understand this work. Fig. 39 may help explain the proposed change of line.

CHAPTER XVII.—MOUNTAIN ROADS.

INTRODUCTORY REMARKS.

1. In the mountains track work differs in many ways from the method usual in lower altitudes. The climate is different, and at an elevation of 10,000 or 11,000 feet the winters are long and summers very short, and a cold wave may bring snow any day in the summer. Of course with the great number of clear days and sunshine enjoyed in the mountains the snow soon melts on the ground, but its fall is a matter of deep concern to the trackman. Cloud bursts or heavy rains in the summer cause land and rock slides, fill canyons and gorges with vast torrents of water that rage and roar in the fury of its onslaught as it rushes through the tortuous course of its narrow bed.

It often comes suddenly, a wall of water from five to ten feet high; then later a great swell that may again double the volume of water, finally sweeping track and grade bridges and piers and all the works of man from its path as if they were but that much chaff. In one hour this noisy besom of destruction may be gone and in its place a tiny brook runs here and there over the clean sand and plays hide and seek among the big boulders. Instances may be cited where track in canyons has been so completely destroyed that not a vestige remains to show that a railroad had ever been built there. The heavy long grades are also a distinguishing feature of mountain roads. They may run up to

150 feet per mile on standard gauge main lines and as high as 300 feet on narrow gauge roads and the grade, be it light or heavy, often stretches out from the summit or pass on either side for hundreds of miles. So much does the altitude affect the climate that the foreman on the pass may be picking ice from the rails in a snow shed the same day that another foreman in the valley, perhaps within sight of the pass and only fifty miles away, is cutting weeds and mopping the sweat off his face. At certain seasons sunshine prevails in the valleys, while the mountain tops are wrapped in clouds which seem to form there as moisture gathers on the outside of a pitcher of ice water in a warm room. At other seasons the mountains stand out clear in the sunshine, while the clouds drift low along the valleys. In the winter the amount of snowfall depends largely on the elevation of the locality, being very light and melting rapidly at the lower altitudes, where the winters are mild and storms infrequent; but the reverse becomes true the nearer one approaches the various passes of the mountains. And what storms! The snowfall at one time may reach a depth of five feet on the level before clearing up; then begin again and add another five feet to it. There was a blockade on the Sierra Nevada one time, when, in spite of all that could be done by rotary and other plows, the traffic was brought to a standstill, and the snow covered the track for several miles near the summit to a depth of thirty feet. Of course in this case a rotary could not be used until the snow was shoveled out, so that its depth on the track did not exceed the height of the upper hood of the rotary. For this purpose over 1,000 men were employed for a week. At another time on a Rocky Mountain road 150 men had been engaged in clearing the line near the

pass, and had finished the work on the last day of April, but the next day were called from their homes again on account of a drifting storm that covered the road in places to a depth of ninety feet. These are exceptional cases, however, and ordinarily the lines are kept open during storms by running rotary snow plows and flangers over the road. After each heavy fall of snow, slides are to be expected. They may start from a point high up on the side of the mountain, where the smooth slope of a cliff has been overburdened with the weight of snow, which, slipping from its moorings, rapidly gains in weight and momentum as it descends, and gathering all the snow in its ever-widening course its front swells up ten or perhaps fifty feet high, and its width two or three times as great, while it rushes downward, carrying with it great rocks and trees that have been snapped off at the ground as if they were only stubble. When a snow slide crosses a railroad track considerable snow is deposited, usually filling up the break in the incline of its course and packing it very hard. For this reason, and the fact that the slide always contains rocks, logs and brush, a rotary cannot be used where a slide has crossed, but it must be shoveled out.

A traveler used to the straight track and direct routes of Eastern lines will find himself nonplussed at the great variety and extent of the curves on mountain roads, and the apparently aimless wanderings of the line which take him here and there, back and forth, first north, then east, then south, then west, in a way to convince him that the line was laid so as to get as much mileage out of him as possible, or that the engineer who laid it out had a severe brain attack of St. Vitus' dance. But in reality, this apparently hopeless confusion is the result of much study on the part of

the best engineering talent in the United States. And the curves! What with wide, deep chasms ahead, peaks and gorges to the right, cliffs and precipices to the left and solid granite walls thousands of feet high and miles thick behind, is it any wonder there are curves? But there are other reasons for curves and crooked track. Suppose the line has followed a valley up to a certain point at an elevation of say 4,000 feet, where it is necessary to leave the valley in order to cross a range of mountains whose lowest available pass is 11,000 feet high. Now, suppose that the maximum grade allowed was 100 feet per mile, and it was twenty miles in a direct line from the point mentioned in the valley to the pass. No matter how tempting this direct line may be, it would be useless, because the grade would be too great—350 per mile. In order to reduce this to 100 feet the engineer must make room for seventy miles of track between these two points to gain the desired 7,000 feet in elevation, and in surveying he may wander back and forth across the direct line as often as he wishes, or put loops in it if necessary to get in the extra fifty miles of track. But while doing this the engineer never forgets the pass. Every crook and turn is made with the object of getting a uniform grade from beginning to end, and the experienced engineer will, when nearing the summit, especially, run his lines so as to get as much track as possible on the south slope of the mountains, where the rays of the sun clear the ground of snow fully two months earlier than on the northern sides. The following pages are intended to cover only points peculiar to mountain track work that are not more fully set forth in other chapters.

TRACK WORK.

2. The winter should find trackmen in the mountains well prepared for the most exacting part of the

year's work. The ditches should be cleaned out and all loose rock should be barred down from overhanging walls, otherwise, later, they may be dislodged by the expansive force of ice or by weight of snow and roll on the track. If the cut ends abruptly at a deep fill, the ditch should be extended away from the track along the side of the hill in order to prevent the water cutting unsightly holes in the grade at the end of the cut. At many places the cut is on one side only, the other side being a fill, and where the formation is loose rock, gravel and dirt, and when wet is very apt to slide down. In such cases the dirt is often cast across the track and down the side of fill. After a time this fill becomes so wide at this point that the dirt can no longer be cast over the bank, but must be carried a part of the way. This is a very costly way of doing the work, and if the traffic over the line will justify the use of a push car the dirt ought to be hauled out, and dumped on a fill. When very large rocks are to be barred out or rolled down, they may be made to roll across the track and down the fill on the other side by laying an inclined platform of ties over the ditch next to the hill. But if for any reason the success of this plan is doubtful or if the walls of the cut rise on both sides of the track such large rocks should be blasted before being moved, so that the track may not be obstructed with rocks too large to handle. In all cases the rails below the rock should be protected by ties. If the rock is to be rolled the ties should be laid along each rail on the side next to the hill, but if blasting is to be done a row of ties should be laid along each side of each rail for forty or fifty feet near the point where the largest rocks are expected to fall. If sufficient ties are not at hand to do this a single row laid on top of the rails may do, but in this case there is danger of a tie being displaced by one

stone and leaving the rail exposed to damage by a heavier one coming after. If ties are not to be had poles may be cut and substituted. All such rock work should of course be done under protection of flags. Cross drains should be cleared out, and if the lower end empties on loose sand or soil it should be filled around with rock to prevent washing or undermining the drain. All loose, coarse rocks projecting above the ties in the track should be removed before winter sets in, otherwise they may become displaced and later roll on the packed snow or ice between the rails and strike a cowcatcher, snow plow or flanger.

PROTECTION AGAINST SNOW.

3. All roads crossing the different ranges maintain an expensive system of snow fences and snow sheds. At the higher altitudes, on account of the excessive amount of snow fall, fences are ineffective and sheds are built over cuts and other places where the snow is liable to cause trouble, while the fills are generally left exposed because the winds may be depended upon to keep them clear. Where the elevation is not great snow fences are in a measure depended upon to keep the snow from drifting upon the track. The point of elevation at which fences are no longer effective and sheds should begin varies greatly in different parts of the country, and must be determined by experience in each particular case. Sheds and board fences are always built by the B. & B. department, but trackmen are generally expected to look after them, and do light repairs, remove grass and other combustible material from sheds, and see that water barrels are kept filled. During the winter the railway companies should furnish common salt and about two common water pails full should be put in each barrel when cold weather sets in, and that amount of salt will prevent the water

freezing hard enough to injure the barrels. Before putting in fresh salt the old salt, stones, dirt, etc., should be cleaned out. If the company does not furnish salt for this purpose, the barrels should be turned bottom side up to prevent injury from freezing or stowed in some safe place.

CLEAR RAILS OF ICE.

4. Particular attention should be given to keeping the rails in snow sheds and tunnels free from ice in the winter. In case the snow shed is on a side cut the ice may be thrown outside through one of the windows or openings on the lower side, but if the ice cannot be disposed of in this way, as is the case in tunnels and thorough cuts, it should be hauled out on a push car. It is not necessary to do this every time the rails are cleared, but only when the loose ice is piled up so that it is getting too close to the track. These piles of ice should not be allowed to remain in the tunnels or sheds in the spring, as ice melts very slowly in the shade at high altitudes, and will keep the track wet for a long time after the ground is dry where it is exposed to the rays of the sun.

MAKING SNOW FENCES.

5. Sometimes trackmen are required to make a snow fence out of poles where timber is convenient. If the ground is not rocky a good fence may be made by beginning at one end and setting an upright forked post; then lay one end of a pole on the ground and the other projecting through the fork of the post. The poles should be about twenty feet long, and the upper end should be about eight feet above the ground. After setting the first pole in position, drive cross stakes about four feet from the upright post so they will lap over the inclined pole; then lay another pole in the crotch thus formed by the stakes and repeat the

process until the fence is finished. The cross stakes may be made from the top or branches of the poles cut. This makes a good snow fence, but requires a great deal of work to make it. Another form adapted to rocky ground where stakes cannot be driven is the old-fashioned worm fence, largely used by farmers in the East before the advent of barb wire. This form of fence, while not as effective as the first, is cheaper and does fairly well. Still it costs considerable to maintain any of the different forms of snow fences now used. They break down, blow down, burn down, or rot down and are a continual source of expense.

THE ROTARY PLOW AND FLANGER.

6. The modern rotary snow plow and flanger put a quietus on the old snow plow, and "snow bucking" outfit, which were always costly and hardly ever effective in keeping the mountain passes open for regular trains. If the rotary plow and flanger are kept patrolling the line during a storm the section men—outside of a small gang kept with the plow, will have little snow shoveling to do except at switches, depot platforms and snow slides. Turntables on the passes are usually housed in and require no attention.

WATER SUPPLY.

7. Foremen are often bothered about keeping up the flow of water in the tanks. Those located in the mountains are generally supplied by gravity; that is, there is an underground pipe line extending from the tank to a point on the line of some stream where the intake or upper end of the pipe is higher than the tank. The line is usually laid so deep that there is little danger of freezing, but as an additional precaution the lower end is provided with a waste pipe arranged so that when the tank is full a valve in the lower end of the

pipe line is opened and the water flows through a waste pipe until the water in the tank is lowered by engines to a certain point, when this valve is again closed. By this arrangement water is always flowing through the pipe line, and the probability of its freezing up reduced; but the box or housing at the upper end is often broken or filled with sand during a freshet and should be promptly dug out and repaired. It is a very difficult matter to protect the upper end of the pipe so as to admit water freely and still keep out sand and silt. Shallow, wide wells with cemented rock walls and tight covering are superior to the many boxes, filters, etc., used to keep out the sand.

HANDLING HAND AND PUSH CARS.

8. On grades exceeding 2 per cent. ordinary hand cars cannot be operated to advantage on account of the loss of power resulting from the poor mechanical arrangement with which they are usually equipped. On such grades push cars are used, and as the sections are rarely over four miles long the loss of time going to and coming from work is not much more than if hand cars were used, on account of the necessity of flagging around the numerous curves. Before starting down grade on a push car the foreman should see that it is supplied with a good hard wood brake stick, and if two are to be had, so much the better, as one is liable to break or drop out of the hand of the one manipulating it. When the rail is covered with frost the loose wheels should be ahead when going down grade, in order to clear the rail as much as possible, so that the rigid rear wheels may not slide when the brake is applied to them. When the grade is not heavy enough to bar the use of hand cars the common brake apparatus will not always supply the desired retarding power, and should be re-enforced by one of the many devices

used in the mountains for that purpose. As they are all simple in construction and depend largely on the style of hand car used, a description of them need not be given here. Towing a car behind a freight train is rather dangerous, and is generally forbidden by rules, but those rules are nevertheless violated in some cases. After one has put in a hard day's work the prospect of pushing a car loaded with tools up a heavy grade for three or four miles tends to give one "that tired feeling," and if a freight happens along about that time the temptation to "hook on" and ride is almost irresistible. This may be done with greater safety if, instead of having a long rope and trailing the car far behind and running into the caboose every time it stops or slacks up, the car is brought up tight against the brake beam and held there, or if the car frame is too high for the beam stick a long handled track wrench down through the draw bar and hold the car against that, and it will ride steady. The men should always ride on the platform of the caboose, and when it is desired to stop, they may step down on the car and cut loose from the train. As the trains go slow up grade there is little danger in this method as compared with the practice of trailing with a long rope and having all the men ride on the push car, which was sure to run under the caboose platform and hurt some one. Still, no matter how safe it may be, it is safer to obey the rules—and walk.

FLAGGING.

9. When flagging up grade the man sent ahead may often take a short cut from one track to another higher up and save time, but he should never leave the lower track until the men behind are in a position to see far enough ahead to note any train coming before the flagman reaches the upper track. Very little flag-

ging ahead is required going down grade, because there is generally a heavy smoke issuing from engines coming up, and there is little danger of being caught from that direction. But no chances should be taken of being run into by trains coming down grade.

EXPANSION.

10. The contraction of rails on mountain roads in the winter does not seem to be greater than on other lines. This is probably accounted for by the fact that while the temperature falls very low in the winter it does not rise high in the summer, so that the range is not excessive. This fact should not be lost sight of in track laying or relaying steel. The greater the altitude the less expansion needed if the rails are laid in the summer. The rails do not absorb the heat of the sun and become so much hotter than the temperature of the air as they do at lower altitudes. At some passes the thermometer never rises above 80 degrees, and in such a case steel laid when the temperature reaches this point would need no expansion, because whatever movement takes place must be in the way of contraction. Yet steel is often laid in the mountains with the same amount of expansion required by rules intended and accepted as correct for use in other climates, and where this is done the contraction during the nights, which are always cold in the mountains, and in winter, is so great that the joints are pounded down and rail ends battered by the wheels and frequently the bolts are broken and the rails pull apart. In another part of this volume an excellent method is given to remedy too wide openings at the joints.

RAILS ON CURVES.

11. Where curves are numerous the "butting back" process mentioned should begin at the short rails usu-

ally laid at each end of a curve on the inner line of rails, if the curves are laid with broken joints. But if curves are laid with even joints they will be found to contain some twenty-nine or twenty-nine and one-half foot rails, and the closing up process should be done with a view of taking out these rails and using longer ones. When reverse curves are close together by changing rails on the inside of one curve the expansion may be adjusted on the outer rail of the next curve and this plan may sometimes be followed from one end of a section to the other. Thirty-foot rails should not be taken out and short pieces put in when closing up expansion if it can possibly be avoided. In theory each rail should have a certain amount of space between it and the next rail, but in closing up extra expansion this need not be done. If a piece of track, say sixty rails long, has one-third more expansion than necessary, begin at a point near the upper end if on a grade say twenty miles from the top of the hill, and butt back ten rails in each direction; then by leaving the bolts loose and slot spikes out the heat will, on the first warm day, move the rails so as to absorb much of the extra expansion at the joints of the other rails when the bolts may be tightened again and the slots respiked. This work is usually done in the winter, when the force allowed is not sufficient to justify the foreman in undertaking to close up the extra expansion at each particular joint.

BROKEN BOLTS.

12. Whenever a sudden fall in temperature occurs the trackwalker should be instructed to look carefully for broken bolts, and the foreman should see that they are replaced at the first opportunity. Often rails are found with one or two holes bored in the wrong place. They may be too close or far apart to match the

holes in the angle bars, or the fault may be in the angle bars. In either case the strain of contraction is not shared by all the bolts equally, but falls on one bolt at a time, and they are thus broken in succession and the rails pull apart and the ends get battered. It does not help matters to drive the rails together and put in new bolts, because they, too, may be broken the next night, and it is not unusual to see half a peck of broken bolts lying on the ground near some of these misfit joints. The only remedy is to measure the distance between the bolt holes in the angle bars and between the holes in the rails, and whichever varies from the standard should be removed and put in some siding, where it can do no harm. The fault is nearly always found in the rail.

CREEPING OF RAILS.

13. The creeping of rails on roads having little or no grades is generally in the direction of the heaviest traffic, but the traffic does not seem to have much influence on the creeping of rails on heavy grades. If the trains moved the rails in the direction they take and the rails on the east slope of mountain moved east or down grade, it might be expected that the rails on the west slope would creep in the same direction, or up hill, but such is not the case, and it appears that on single track lines, where the grade is heavy, the rails invariably creep down hill. It is possible that this seeming reversal of a generally accepted rule is caused by the continuous application of brakes required on trains going down long, steep grades. The creeping of rails on mountain roads, however, is not as great as one might expect. The good ties, the bracing and careful spiking required to hold the rails on the curves all tend to prevent excessive creeping. Years ago, on a certain narrow gauge line, attempts were made to hold the rails on a grade exceeding 4 per cent. by an-

chorage. Holes were drilled in solid rock at convenient points and iron bars inserted and secured by pouring in hot lead; then the other end of the bar was fastened to the straps at the joints. This plan was a failure, as the bolts always broke either at the joint anchored or at some joint below it. Of course, if every joint could be anchored, it might prevent creeping, but this could not be done, because solid rock could not be found at every joint, and the expense of making anchorages would be too great. The plan was a failure, therefore, because each rail could not be secured to something solid, and then the fact was evolved that in order to hold the rails on a heavy grade each one must be anchored and the amount of creeping would depend upon the security of each anchor. Then it was ordered that shoulder and joint ties be properly spaced (this had been entirely neglected), and each rail securely slot-spiked to sound ties. This checked the creeping to a great extent, and is the only inexpensive plan that will do so. If track is laid with broken joints a hole should be drilled at centers and an old angle bar bolted on and spiked to joint ties to prevent them being slewed by rails creeping. This also more than doubles the resistance to creeping.

WASHOUTS.

14. In the spring mountain roads are subject to considerable damage from washouts. These occur not only along water courses, but also in the parks and valleys where the ground is comparatively level and where the track may be some distance from a stream. A peculiarity of mountain streams is that they rarely cover any considerable territory. There are points where clouds seem to gather or form, and sometimes the fall of water at these places may amount to two or three inches in a few minutes. The down-pour of these

so-called cloud bursts is something tremendous, and of course in such a case the nearest stream is changed in a short time into a torrent, along whose bed are rolled enormous boulders, which strike and break off bridge piling as if they were pipe stems. At other times a cloud may leave some peak or range and, swelling up big and black, move out over a valley and suddenly dump almost its entire contents in a forty-acre field. If there happens to be a railroad track whose grade is not much above the surface of the ground in this place, it will be flooded or the ballast washed out from between and under the ties. Foremen in the valleys soon learn to watch certain points in the mountains for storms that may cause damage to the track, and when it is evident that a serious storm is in progress at such a place, flagmen should be sent out to watch the effect on bridges spanning the streams involved, and these watchmen should not be withdrawn until all danger is known to be past. If the storm in the mountains lasts one hour the flagman should stay at the bridge for one hour after the water begins to rise. It would not be safe for him to leave after the water begins to recede, because it may begin falling within five minutes after the first rush of water, and then in a short time double the volume begin pouring through the bridge. This may be caused by some other stream covered by the storm emptying its flood into the first, thus swelling a stream already full. Track high up in the mountains or near the passes do not suffer much from wash-outs, because the streams are necessarily small and are usually confined within rocky walls, and also on account of the broken nature of the surface, the ground being cut up by numerous gorges and canyons, so that the waters do not unite until some point in the valley or at least a lower altitude is reached.

LAND SLIDES.

15. The melting snow in the spring at high altitudes softens ground to such a depth that the sandy cuts are always caving in or loose rocks rolling down. Most of these cuts are side cuts, having one high wall next to the hill and little or no cutting on the lower slope. Most of the slides are small and do not cover the rails. But if the slide cannot be removed by the section gang without delaying trains too much the foreman should go to the nearest telegraph office and notify the roadmaster and superintendent, stating number of feet of track covered, how deep, and whether with gravel, clay or rock. If the latter, the foreman may expect to find some of the rails bent or broken, and should have other rails at hand ready to replace them as soon as the track is cleared. Before the foreman calls for help to remove a slide he ought to calculate the probable length of time it would take before assistance could arrive, and if it is possible for him to clear the track in that time he should not call for help even if he does delay a train or two which could not be avoided anyhow.

BLASTING ROCKS.

16. At points where large rocks are liable to roll on the track a supply of drills, giant powder sticks, and fuse and caps should be secreted in some convenient place known to the trackwalker and foreman. If a rock too large to be rolled is found on the track it may be broken by fastening two sticks of giant powder together, attaching the cap and fuse, and laying it on top of the rock on a flat surface, if possible. Then, if a smaller rock is laid on top of the giant powder, much additional force of the explosion will be exerted downward. Sticks of giant powder should never be hung

over the side or laid beneath a rock laying on the track, as the explosion is certain to injure the ties or rails. If the rock is too large to be broken in this way it must be drilled. A hole equal in depth to one-fourth the thickness of the rock will be sufficient and half a stick of giant powder, properly tamped, will rend a rock weighing several tons. But it is best to use a liberal quantity of powder, so that the pieces may be small enough to be handled readily. If a shot misses—that is, if the fuse fails to carry the fire to the cap or the cap does not explode—the hole should not be picked out, as the drill is liable to strike fire and ignite the fuse, or it may hit the cap and cause it to explode. In picking out missed shots it is customary to pour water in the hole and depend on it to prevent an explosion, but as the cap and powder are not injured by water and the fuse may be used under water the safety of the plan is doubtful. A reliable authority asserts that 20 per cent. of missed shots that are picked out result in premature explosions, and this relates to miners who are supposed to be experts in drilling. It may take a few minutes longer, but it is much safer to drill another hole a few inches from the first. Only experienced men should be allowed to handle giant powder, and it should never be carried in the well or bed of a hand car, as a collision may take place or something be dropped on it and cause an explosion. If it is necessary to carry a few sticks along on a car they should be taken in the pocket or hand of some one who will take care of them. Frozen giant powder will not explode, and must be thawed out by a fire or in warm water. It may be kept in a box in the bunk house under a bed during the winter to prevent freezing, or if this plan, which is perfectly safe, but calculated to give one the nightmare, is not relished by the men, the sticks may

be kept from freezing by putting them in a large-mouthed jug or can and corking it tight; then sink the powder so that it will not freeze in some stream that flows all winter. A few sticks secured in this manner may be distributed along the section, and be found ready for use at any time, and save the long wait required to thaw out frozen sticks or go to the bunk house for others. The uncertain and treacherous nature of giant powder requires that extreme care be exercised in handling it.

PROTECTING EMBANKMENTS.

17. Much trouble is often experienced in protecting railroad embankments from being cut away by the current of mountain streams. If the track is in a narrow canyon where the water runs swift and deep, solid masonry walls afford the most reliable protection; but if the width of the stream will permit a good wall having a slope of one in one may be made of uncut sandstone by using selected stones from two to three feet square and from six to twelve inches thick. The foundation should, if possible, be laid on bedrock, but in the absence of this the foundation may be made of loose rock, laid in a trench about six feet wide and at least three feet below the line of scour in the bed of the stream. Much depends on getting down below the line of shifting sands during high water, and allowance must be made for the increased depth of scour that may be caused by the water being deflected or confined by the wall. After the loose rock is put in place and interstices filled with sand a line of the large square stones may be laid on top with the face in the center of the foundation and backed by loose rock carefully packed and to a height equal to the top of the first line of stones. Then another layer of stones may be laid on the first, but at a distance back of the first

line equal to the average thickness of the stones, when the backing may be again brought up to the level of the stones, and so on, making a wall somewhat like a stairway the height and width of the steps being equal. This makes a good, strong wall at a cost less than solid masonry, but like the masonry its life depends largely on the security of the foundation. When sandstone is not to be had, such walls are often built, but without the steps, of smelter slag. This is melted rock, and is heavier than sandstone, and when well laid with the smooth side out presents a nice appearance. But it is impossible to make the pieces fit closely, and being small, they are easily knocked out of place by floating driftwood, logs, etc., and if the current is swift, in a few years the carefully laid wall looks like common loose riprapping. Where the width of the stream is ample, or where there is no reason for building masonry or other walls, ordinary riprapping may be employed to protect the embankments. This consists of dumping stones, slag or like material over the bank of the river until it is entirely coated from top to bottom to a depth of from perhaps two feet at the top to ten feet or more at the bottom, depending on the shape of the bank and on the slope given the riprapping. No foundation need be provided, as the loose rock will roll down and fill up any holes scooped out by the water. The amount of rock on the side of the bank should be in proportion to the depth and volume of water that may pass this point when the river is full. If the course of the stream lies parallel with the track the slope of the riprapping may be about one to one and one-half; but if the water strikes the bank at an angle the lower half of the slope should be at least one to two. It may be frequently noticed that a bar of loose boulders a few feet high and sloping into the

water at a slight incline will hold their place and turn the course of a stream. No one doubts that if a wall of these same loose boulders was run out into the stream it would be swept away by the first flood. This shows that the current of a stream cannot be turned by loose rock unless it is laid with a long slope or incline, and the longer the incline, especially the lower portion, the greater will be its power of resistance.

Stone cribs laid parallel to the track or projecting down and outward into the stream are used in many places to prevent the water cutting away the bank. They are simple in construction, being long boxes made of logs properly notched at the ends, laid somewhat like the walls of a log cabin, or they may be made of timbers. In each case they are drift bolted at the corners and through the cross stays, which may be placed in rows about ten feet apart, and then the whole is filled with loose rock or slag. When laid on a good foundation they answer the purpose for which they were built very well; but there are objections to them. The cost of material and labor required in building the crib is considerable. Then there is danger that high water will go through and undermine the bank behind them, especially if the latter be sandy, or in the case of wing dams or cribs it is liable to cut around the shore end if it is not well protected, form a new channel and leave the crib on the other side of the stream, and, finally, it is certain that as the timbers cannot be replaced at any reasonable cost when they rot, the whole fabric must sooner or later give way and leave nothing but a poor job of riprapping to show for all the work done.

WIDENING GAGE AROUND CURVES.

18. There seems to be no decision reached as yet by trackmen as to whether the gauge of curves should

be widened. Many instances are cited by writers in railroad journals of cases where more or less difficulty was experienced in keeping sharp curves from spreading until the gauge was widened, when it is claimed all trouble from this source disappeared. Such statements frequently made by reliable authorities would seem to settle the matter in favor of widening the gauge. On the other hand many competent trackmen stoutly maintain that this is not necessary; that it is a needless expense to do so, and at best only a matter of

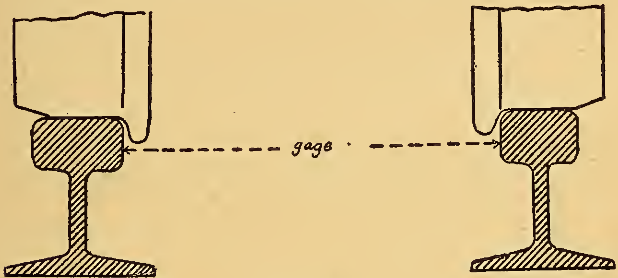


FIG. 40.

guesswork, and proceed to fortify the statement by referring to curves equally as sharp as those mentioned by their opponents where no trouble is had in maintaining standard gauge. Now, it is known that there is considerable variation in the length of wheel base, and in the arrangement of drivers in various engines, and the difference of opinion may be accounted for by the results of engines of different design running around curves of the same degree. A close examination of the subject would take up too much space, because the form of rail head, or at least the radius of the upper corner has considerable bearing on the point at issue. This may be better understood by examining Figures 40 and 41 from the following drawing. It

will be seen that there is room for much more lateral motion between the wheel and form of rail heads shown in Fig. 41 than in Fig. 40, because the shape of the side and radius of the upper corner conforms more closely to that of the wheel flange. In Fig. 40 there is less than three-fourths inch difference between the wheel and rail gauges, while Fig. 41 would permit a lateral movement of the wheels of one inch or more. Laying this matter aside, however, let us see what effect the length of rigid wheel base has on curves.

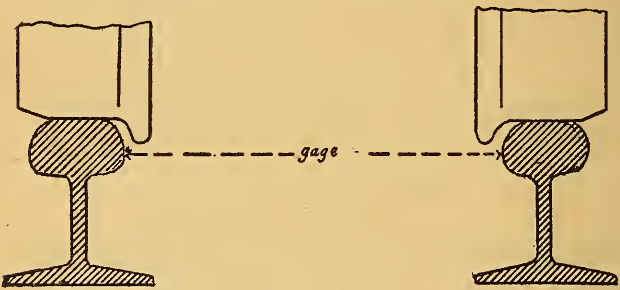


FIG. 41.

In the first place, it is certain that curves need not be widened for an engine with but two pair of drivers, because no matter what distance apart they are each set of wheels can touch but one rail at a time; therefore no spreading of the rails can take place.

With three pair of drivers, it would be different if all were flanged, but either the first or second pair of drivers is blind, which makes the conditions the same as if but two drivers existed, as stated above. But such engines often have two pair of truck wheels that turn on a pivot under the front end of the boiler, and while they are not considered in the rigid wheel base of an engine, still they have considerable bearing on the question at issue. The amount of "play" or lateral

motion of the trucks depends on the arrangement of springs, journal boxes and pivot, and may safely be set down at one inch; this, in addition to the three-fourths-inch play between wheel and ordinary rail head. Now, the total wheel base of such an engine may be said to be twenty-six feet, but for our purpose the wheel base may be calculated to stop at the pivot, because the wheels of the forward truck adjust themselves to the line of the curve. Therefore, half the distance between truck wheel centers may be deducted from the total wheel base mentioned making it about twenty-three feet. (See Fig. 42.)

The middle ordinate of the rail between wheels a and b and the one-eighth-inch lateral motion in

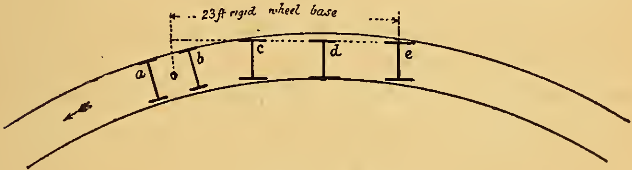


FIG. 42.

drivers need not be considered in this case. Assume that the drawing indicates the position of the wheels on a 14 degree curve. For 23 feet the middle ordinate is 1 15-16 inches. The dotted line shows the center of the trucks to be $1\frac{3}{4}$ inches inward from the rigid wheel base line of the drivers, that is, counting 1-inch lateral motion in the pivot and $\frac{3}{4}$ inch between wheel and rails. When the engine is not going fast the rear driver e will follow the line of the inner rail. The wheel flanges will then be in the following positions with reference to the outer rail a and b (truck wheels) touching the rail—c forward flanged driver $\frac{3}{4}$ inch away—d blind driver 1 5-8 inches away, and e rear flanged driver $\frac{3}{4}$ inch away. The position of the blind

driver (d) with reference to the outer rail still leaves a full rail under the wheel, its inner edge being about on a line with the gauge side of the rail. On such a curve this engine would be guided by the truck wheels, the flange of the front driver being $\frac{3}{4}$ inch away from outer rail. If the truck had a swing bolster the forward driver flange would touch the outer rail. As it is, the engine will ride freely around such a curve, not binding at any point. It is claimed that the gauge should be widened because the rear driver flange runs against the inner rail, but as the pressure against the inner rail is probably less than half that of the forward wheel against the outer rail this point is not well taken. But if the gauge was widened the wheels would still flange the inner rail, not with so much force, perhaps, but the pressure against the outer rail by the front wheel would be increased because of the engine being at a greater angle to the line of the curve. Much space has been given this particular type of engine, because it is the hardest on curves, on account of the small amount of lateral motion allowed by the pivot. On nearly all mountain roads the pivot is not used, a swing arrangement that allows three or four inches side play being substituted, which does away with the necessity of widening the gauge on any curve, because only the forward and rear drivers need be considered, and no cramping between flanges and rail can take place. This swing bolster is also used on all engines having but one set of wheels, or pony truck in front. This pony truck is mostly used on freight engines having four pair of drive wheels. Two drivers only being flanged and the first and third or the second and third being blind. The fourth or last driver is always flanged, so that the engine will not leave the rails when backing up. The gauge of curves need not be widened

for this class of engines, because the flanges cannot bind between the rails.

Enough has been said, however, to show that the gauge of ordinary curves on main track need not be widened and but very little on sidings, Y's, etc., where the curvature exceeds 14 degrees, and then only in case the long wheel base, pivot truck style of engine referred to in the drawing uses the track.. Some argue that if the gauge is widened the wheels of freight cars will move with less friction around a curve, and the train pull easier, but as their short wheel base does not permit the flange of either inner wheel to touch the inside rail there appears to be no reason why this should be true. The gauge of track should never be widened only where the necessity, for it can be clearly shown. Trackmen should hold their ground on this question. If they give way and widen the gauge on curves for the present type of locomotives they may in a few years have to widen it still more for some other style. The master mechanic might just as well make up his mind to build an engine that will fit a standard gauge curve as to build one for a 4 foot 9 inch or 4 foot 10 inch curve. The pivot truck locomotives referred to are used on many Eastern roads, and should be abolished as a nuisance. If the swing bolster type can be used with perfect safety without widening gauge of curves on crooked roads of the West, why can it not be used on the comparatively straight lines of the East?*

*At the meeting of the Roadmasters' Association of America, held at Denver, Colo., Sept. 13, 1898, the report of the committee appointed to examine this question favored widening gauge of curves exceeding 6 degrees, in spite of the fact that Western roadmasters asserted that they had curves of from 16 to 20 degrees which they had no trouble in keeping at standard gauge. In fact, Mr. Brinton, of the Colorado Midland, asserted that he had trouble with a 16-degree 40-minute curve, which was one inch wide gauge until in relaying it with new steel he decided to bring the curve to standard gauge. Since then the wear on the outer rail has been less and he has had no further trouble with the curve. The report of the committee is theoretical and contrary to established facts. No mention was made of blind drivers nor their influence on this subject.

CATCH SIDINGS.

19. Catch sidings are used on several mountain roads where the grade is heavy, to stop and hold trains that have got beyond the control of the trainmen. Instead of using a derail the idea is to gradually check the speed of the train by turning it into a spur whose rapidly increasing grade rises toward the rear end which may be 100 feet higher than the main track at the switch. The normal position of the switch is for the siding, and the switch tender will throw it to the main track only when signaled to do so by the engineer. No runaway train or detached parts are allowed to pass. On account of the great speed with which runaways enter the spur the switch should be located on the outside of curves of 5 degrees or less, so that the turnout into the spur will not be sharp enough to cause a derailment. But if such a location cannot be made, and it is necessary to locate the switch on straight track, a No. 12 frog should be used, and if small track ties, instead of regular switch ties are used, the elevation for the turnout may begin near the head block and increase toward the frog. By this means the usual flat curve through the switch may be largely avoided and the danger of derailment diminished. There should be no sharp curves on the lower end of the spur, and all curves at this place should have at least one inch elevation for each degree of curvature. This elevation may be decreased gradually on each curve toward the upper end of the spur. Foremen should instruct trackwalkers to look over this spur daily and remove any rocks, brush or trees that may have fallen on the track. The switch tender is not allowed to leave his post to do such work.

WORK IN TUNNELS.

20. Repairing track in long, dark tunnels presents problems to the section foreman not often encountered elsewhere. They cut through formations ranging from loose sand or clay to solid granite. They may be straight or curved, level or with a grade uniform from one end to the other, or from the center each way.

If lined with brick or stone they are usually dry; if wood is used there may be wet spots in the tunnel when the water leaks through. If the tunnel is through rock, seams or cracks are often found through which water pours the year around, and in the winter it requires considerable labor in such a tunnel to keep the rails free from ice and attend to the heaved places in the track. In all wet tunnels the ballast should be broken stone and as deep as possible, but should not extend outside the ties, in order that ample room may be left for drainage. If a rock tunnel has but few seams in it, the water may be kept out by filling them with good cement, but if the rock is badly cracked this could not be done without considerable expense, although it would probably pay in the end and should be done before the track is laid. Iron pipes and tiling are not always reliable at high altitudes, because they often freeze up in the winter. Open ditches are in most cases relied on to carry off the water, and as they do not fill up except with ice in the winter they are about as good as any system of pipes or tiling. In dry tunnels gravel or cinders, or in fact any material makes good ballast, because it is not affected by wet weather. Track in tunnels cannot be raised without diminishing the clearance overhead. This clearance is a matter of record in the office of the chief engineer and superintendent and is referred to when it is necessary to know whether any extra high car or load may be

safely sent over the line. Therefore foremen should not raise track in tunnels without permission from the roadmaster. Before raising track the foreman should about every fifty feet measure the distance from top of rail to roof of tunnel, and if there be any variation (which may be caused by only part of the track in the tunnel having been raised at some time), the track should be raised so that it may be taken out or at least not increased. The width of tunnels for standard

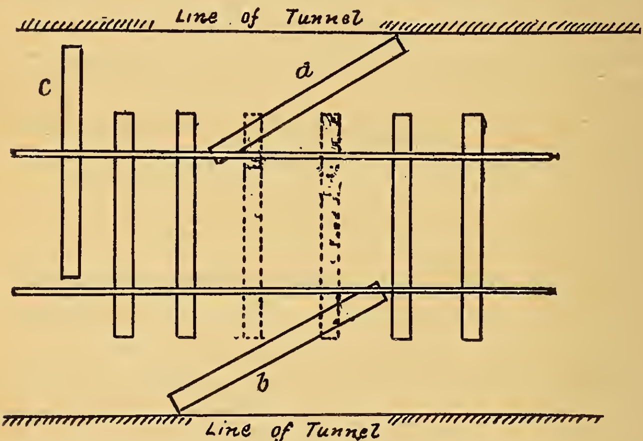


FIG. 43.

gauge track is never less than thirteen feet, and when putting in ties in rock tunnels, it is cheapest to take out two adjoining ties at a time, even if one is sound and must be put back when the new tie is put in. Fig. 43 will show how ties may be taken out or put in where the width of the tunnel is thirteen feet or more and the ties do not exceed eighteen to the rail.

One tie (a) is taken out on one side and slewed in one direction, and the other (b) on the opposite side and slewed the other way. Where rock will not inter-

fere ties may be taken out by digging a trench (c), sloping from the rail down and outward to the wall of the tunnel, then pull the tie to that side until the other end can be raised over the other rail and the tie pulled out. As the back end of the trench need be only about a foot deep, less ballast is handled than in the first method, which should be employed only where a trench cannot be dug. To line track in a long tunnel, get a pole long enough to reach from wall to wall at a point level with the top of the rail, then find and mark the exact center. Next make a mark at the center of the rail gauge, lay the gauge and the pole across the track side by side and throw the track until the mark on the gauge comes even with the mark on the pole. This may be done to get centers at points fifty feet apart, and then the track can be lined according to those points. If the tunnel is dark a torch or lantern may be held over the rail to give light. The foregoing in regard to tunnels will apply also to track repairs in snow sheds.

CHAPTER XVIII.—FROGS AND SWITCHES.

TURNOUTS.

1. A turnout is a curved track, by which a car may pass from one track to another, and consists of a frog, a rail leading to the frog, a corresponding opposite rail, and a device connecting these rails with the main track, called the "switch." If a switch is made to

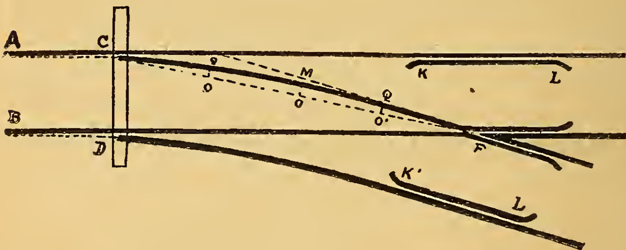


FIG. 44.

serve two turnouts, it is called a "three-throw switch;" a "trailing" switch is one where a train on the main track passes from frog to switch; while a "facing" switch is one that approaches in the opposite direction.

The common or "stub" switch consists of a pair of connected rails, AC and BD, Fig. 44, so arranged that while one end is fixed, the other can be moved so as to be a part of either the main track, or turnout. The fixed end is called the "heel," and is the beginning of the turnout curve. The other end is called the "toe," and the distance it moves in passing from main

track to the turnout rails is called the "throw." The toe rests on a large piece of timber, called the "head block," on which are placed the "head chairs," and "switch stand." The portion of the turnout between the head block and frog point is called the "lead." The "total lead," includes the switch and lead rails. The turnout curve is from A to F, and should be a simple curve considered as joining the two long ends; one of them, IF, is the turnout line of the frog produced, until it intersects the opposite rail; the other, IA, is the opposite rail. As two tangents to a curve from any point are equal, IF and IA are equal. The length of lead depends on the gauge and frog number, and is equal to the gauge multiplied by twice the frog number. The switch rails are spiked for a certain part of their length, then when they are thrown, the free end will bend to an arc of a circle, and fit the line of lead. KL and K'L' are guard rails, MO is the middle ordinate of the chord CF and QO and Q'O' quarter ordinates.

The stub switch has two serious defects, one of which is want of safety. Statistics show that a large per cent. of derailments are caused by defects and misplacements of stub switches. The second objection is the necessary space at the end of the moving rail, which jars the rolling stock, batters the switch rails, and causes some discomfort to passengers.

"SPLIT" OR "POINT" SWITCHES.

2. In order to have an unbroken bearing for car wheels on the track rails, the "split," or point switch was devised. Figs. 45 and 46 show these switches in their simplest form. Fig. 45 shows the switch set for side track. Fig. 46 shows it set for main track. The rails, AB and GD, called "stock rails," are continuous and spiked their full length, the point rails, E and

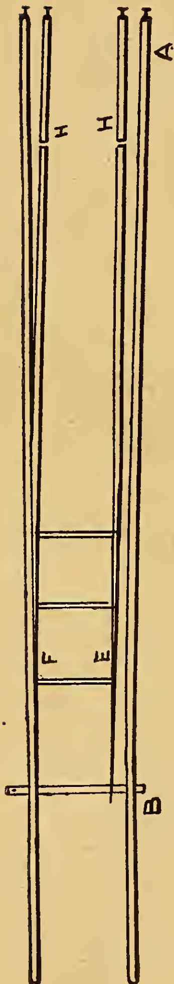


FIG. 45.

FIG. 46.

F, are usually fastened at their heels, HH, by fish-plates to the lead rails. The heels in the split switch are in the places occupied by the toes in the stub switch, or at head block. The split rails are generally fifteen feet long for all turnouts up to and including switches for leads with No. 12 frogs. Above that number 20 and 24 foot point rails are generally used. It gives the best results, combining strength, ease of handling, and economy of manufacture (a thirty-foot rail makes two). As a rule, they are straight, and planed so that they bear against the rail six or seven feet. The throw of the point is about four and a half or five inches, and the clear space at the heel between gauge lines is about the same distance. In order to determine whether a point is right or left hand, stand at the point of switch and face the heel; the point on the right side is the right hand switch point, and the one on the left hand is the left one.

By introducing a spring or other device in the switch stand, a split switch is sometimes made a safety switch, so that when they are set against a train trailing them, the wheels will push the points aside and leave an unbroken rail for the wheel, running onto main track.

The first cost of a point switch is more than a stub, but the split switch is more economical to maintain and safer, making it the cheaper in the end. There can be no question that it is superior to the stub switch, and is fast superseding it everywhere.

LAYING SWITCHES.

3. In laying switches, whenever possible, locate the frog with a view to cutting the least number of rails. A deviation of 5 per cent. from the theoretical lengths in the table makes but little appreciable difference. After you have determined where the frog point

will come, mark the place on the track rail, take from the turnout table the distance from the head block to point of frog corresponding to the number of the frog which is used, add to this the distance from the theoretical to the blunt point of frog. The head block can now be located by measuring the total distance obtained from the frog point.

Make marks with chalk along the flanges of the rail between the head block and frog, so that the switch ties can all be placed the proper distance apart from center to center. After the switch ties have all been arranged according to their proper lengths, lay them out alongside the track, and see that each tie is numbered, and in its proper place as it will lie in the track. Then take out the cross ties and pull in each tie in regular order.

When pulling the ends of the ties to line, time can be saved by using a gauge, made by nailing a cleat across a piece of board, allowing eighteen or twenty inches to project beyond the cleat. Have this gauge square at each end, lay it with the cleat against the end of each tie and draw a chalk line across the tie at the end of the board, marking all the ties the same length from the end. This chalk line should be at the outside flange of the rail and have the spikes driven in it on the line side. When the ties are all in place under the track, the ends of all the ties will line uniformly. This is a much better way than measuring the end of each tie, with a stick or the maul handle. The switch ties should be put in from either end, just as you have the time to spare between trains. If trains are running close together begin at head block and select the time longest between trains to put in frog and lead. At least two long switch ties should be put in behind the frog

to obviate the necessity of adzing and crowding short ties past each other where the two tracks separate.

No frog should be put down until the main track guard rail is first secure in its proper place, otherwise the first train that comes along facing the frog may be derailed.

Before taking up a rail in main track, cut a rail of a length that, with the frog, will replace the rail taken up, and give the necessary opening at the head chair joint, if a stub switch. Use two full length thirty-foot rails for the sliding rails in stub switches, so that enough of the ends can be spiked safely beyond the switch rods. Have the switch rods an equal distance apart, and use five of them instead of four, if you can get them. Then put the head chairs in position under the ends of slide and lead rails. The rails should be properly curved or the switch can never be kept in a good line. As soon as the rails are connected between frog and head chair the main track should be spiked full, and put to a perfect level surface and line before the turnout curve is permanently spiked. An experienced trackman, with good eyesight, can line the lead curve, but it is better to lay it to ordinates first.

Stretch a cord from point of frog to the toe of switch (see Fig. 44), and mark its center and quarter points. In all stub switches, spike the center to an ordinate of seven inches; and each of the quarters to an ordinate of five and a quarter inches, and this forms the true line of the turnout curve.

As soon as the rods are put on the slide rails and main track is in line, the switch stand should be bolted to the head block and connected to the rails. The switch stand should be placed so as to be seen from the engineer's side of the engine, facing the switch, when possible. The gauge rail of the siding should be

spiked to an accurate gauge to the point of the frog, the same as on the main track. But the curve beyond this may be allowed to vary a little from true gauge to prevent a kink showing opposite the frog, as would be the case if the whole turnout was spiked to accurate gauge. Should it be necessary to widen gauge at the frog, the guard rail distance should be increased as much as the gauge is widened. For a 4 ft. 8½ in. always place the side of the guard rail that comes in contact with the passing wheel, a distance of 4 ft. 6¾ in. from the gauge line of the frog. This gives the guard rail distance 1¾ in. when gauge is exact. If gauge is widened ½ in. the guard rail distance should also be widened. Next lay down the guard rail opposite the frog on side track side and the switch is ready to use.

If it is a point instead of a stub switch, the method of procedure is nearly the same. As the split rails are laid tangent to the curve, the degree of curve and ordinates of the lead will be slightly increased, and should be taken from table 2, if you are not furnished with plans from the Road Department. Bend the stock rail about the proportion of 1 in 40 with a rail bender or jim crow. If the switch is made ¼ inch extra gauge at points, place the angle about 10 inches back of them; if made ½ inch wide gauge, place about 20 inches back. When laying a point switch in connection with a No. 10 frog, it is not necessary to cut any rail, but couple the frog at a joint and use two 30-foot rails between the frog and switch.

To get the radius of a lead, multiply the square of the frog by twice the gauge where the theoretical leads are used, and multiply the shortened lead by the number of the frog where practical leads are used.

The theoretical lead equals twice the gauge multi-

plied by the number of the frog. Shortened lead equals the following:

No. 1 to No. 7 lead equals frog number times $9\frac{1}{2}$.

No. 8 lead equals frog number times 9.

No. 9 and 10 lead equals frog number times $8\frac{1}{2}$.

No. 10 to No. 15 lead equals frog number times 8.

TO CHANGE A STUB TO A SPLIT SWITCH.

4. The attachments necessary to make the change from a stub to a split switch are as follows: Two rails, generally fifteen feet in length, with a part of the top and side of the ball of the rail at one end planed off to a point, hence the name point or split rails.

There are usually four cross rods which are used to connect the two split rails, and are bolted to them either at the flange or through the web of the rails. These rods are generally numbered from the head rod back; the head rod, number one, besides connecting the split rails, is also arranged to be connected to the switch stand and moves the switch. The other rods must then be placed in the order indicated by their number.

There are also wrought iron plates furnished, which are placed along on the top of the switch timbers under the split rails to enable them to slide over the flange of the main rails and lay up close against it, when the switch is thrown to either side. Four of these wrought iron plates have an offset in them. The thick part is placed under the split rail and the thin end reaches out under the main rails. Two of these plates are placed on each side of the track, and one on each side of the head rod. The other plates are spiked down on the timber further back from the point with their end under the split rails and close up against the inner flange of the main rails.

When the throw of the split switch is the same as

the stub switch, the same switch stand will do for either. But if the split switch is to have a different throw, to comply with a standard, the switch stand must be adjusted to throw the switch a proper distance. The difference of half an inch in the throw of a switch stand, or the length of the cross rods will make an inch difference in the gauge of track at the points.

When ready to begin the work of changing the switch, lay down the two split rails upon a couple of pieces of timber, close to the track, in the same position they would occupy in track, and let one of your men bolt the cross rods to the split rails securely; measure with tape line the correct distance from the head chair joint of the stub switch along the moving rails and mark this as the place where the head rod of the split switch will come; a couple of ties can then be removed, and if a double head block is required it can be put in, one on each side of where the head rod will be, with a space of about four inches between them. If only one head block is necessary, put it on whichever side of the head rod that will best accommodate the switch stand. While some of the men are doing the work specified, others may be removing the head-chairs, tie rods and head block and other connections of the stub switch.

One of the slide rails of the stub switch, which is on the side track side of the main track, is named the stock rail in a split switch. This rail should be taken out of the track and bent at a point a short distance ahead of the point of split rail. It should then be put back in the track and bolted to the main rail at one end, and to the outside rail of the side track at the other end. This rail should be bent carefully, so that it will be perfectly straight from the point of split rail, back to a point square with the heel of the split rail.

TABLE 1.—FOR "STUB LEADS." GAGE 4 FEET 8½ IN. THROW 5 IN.

FROG NUMBER.	FROG ANGLE.	Distance on Straight Track Point of Frog to Heel of Switch.	LENGTH OF STUB SWITCH RAIL.	TANGENT.	RADIUS.	DEGREE OF CURVE.	CHORD DISTANCE TOE OF SWITCH TO POINT OF FROG.	FROM TANGENTS: Middle ordinate of outside rail main track straight.	FROM TANGENTS: Quarter ordinate main track straight.	FROM CURVES: Change in middle ordinate per deg. of curve of main track.	FROM CURVES: Change in quarter ordinate per deg. of curve of main track.	Distance from head to middle frog point.	ANGLE OF MIDDLE FROG.	MIDDLE FROG NO.
	deg. min.	ft. in.	ft. in.	ft. in.		deg. min.	ft. in.	in.	in.	in.		ft. in.	deg. min.	
5	11 25	47 1	14 0	23 9	235	24 32	33 4	7	5¼	9/32	7/32	19 4	16 08	3.53
6	9 32	56 6	16 10	28 6	339	16 58	39 11	7	5¼	13/32	5/16	23 2	13 28	4.24
7	8 10	65 11	19 7	33 1	461	12 27	46 6	7	5¼	9/16	13/32	27 0	11 33	4.94
8	7 09	75 4	22 5	37 10	603	9 31	53 1	7	5¼	3/4	9/16	30 11	10 06	5.65
9	6 22	84 9	25 2	42 6	763	7 31	59 8	7	5¼	15/16	11/16	34 9	8 59	6.36
10	5 44	94 2	28 0	47 2	942	6 05	66 3	7	5¼	1 5/32	7/8	38 7	8 06	7.07
11	5 12	103 7	30 10	51 11	1139	5 02	72 10	7	5¼	1 3/8	1 1/32	42 6	7 22	7.77
12	4 46	113 0	33 7	56 7	1356	4 14	79 6	7	5¼	1 21/32	1 1/4	46 4	6 45	8.48

The opposite joint in the main track should then be secured with bolts and fastenings. Next, lift the split rails and lay them into the track, connecting their heel ends, one with the rail leading to the frog, the other with the main rail on the side track side, and as soon as you have spiked the tie plates along under the split rails and made connection with the head rod and switch stand, the switch is complete.

As an additional precaution against track spreading enough to prevent the points lying close to the main rails, a rail brace may be spiked down outside the main rails, just ahead of the switch points. Or better than this is to lean two bridle plates, one on the tie, at the point, and the other immediately ahead of it. These plates extend across the tie and far enough each side of the rails so as the trains cannot rest on them. The heel of a split switch is at the head block of a stub switch, and the instructions here given are based on the assumption that the length of the stub switch lead from the head block to the frog point is correct, before changing the switch.

The heel of the split switch should be square with the main rail, and the distance between gauge lines should be the same on both sides of the track.

TABLE FOR "STUB LEADS."

5. For stub leads, table gives all the data necessary to lay out turnouts, whether single or double, from straight track or curves and for any frog number. In the first column are given the frog numbers, the angles corresponding to them in the second. The third column gives the length of lead, from point of frog to heel of switch. In the fourth, the length of switch rail for a five-inch throw. Columns 5, 6 and 7 show

TABLE 2.—FOR "POINT LEADS." GAGE 4 FEET $8\frac{1}{2}$ INCHES.

Frog Number.	Frog Angle.	Length of Split Switch.	Switch Angle.	Distance on Straight Track from point of Frog to Point of Switch.	Radius of Outside Rail.	Degree of Curve.	Cord Distance from Heel of Switch to Point of Frog.	From Tangents. Middle Ordinate of outside Rail Main Track Straight.	From Tangents. Quarter Ordinate Main Track Straight.	From Curves. Change in Middle Ordinate per Deg. of Curve of Main Track.	From Curves. Change in Quarter Ordinate per Deg. of Curve of Main Track.
	deg. min.	feet	deg. min.	ft. in.		deg. min.	ft. in.	in.	in.	in.	in.
5	11 25	15	1 35	52 6	220.1	26 33	37 9	$9\frac{3}{4}$	$7\frac{5}{16}$	$\frac{3}{8}$	$\frac{9}{32}$
6	9 32	15	1 35	58 11	317.9	18 14	44 1	$9\frac{3}{16}$	$6\frac{7}{8}$	$\frac{1}{2}$	$\frac{3}{8}$
7	8 10	15	1 35	65 1	437.5	13 12	50 3	$8\frac{11}{16}$	$6\frac{3}{8}$	$\frac{21}{32}$	$\frac{1}{2}$
8	7 09	15	1 35	70 11	577.5	9 58	56 1	$8\frac{3}{16}$	$6\frac{1}{8}$	$\frac{13}{16}$	$\frac{5}{8}$
9	6 22	15	1 35	76 6	738.2	7 48	61 7	$7\frac{3}{4}$	$5\frac{13}{16}$	1	$\frac{3}{4}$
10	5 44	15	1 35	81 9	924.0	6 13	66 11	$7\frac{1}{4}$	$5\frac{7}{16}$	$1\frac{11}{64}$	$\frac{7}{8}$
11	5 12	15	1 35	87 1	1143.7	5 01	72 2	$6\frac{13}{16}$	$5\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{1}{32}$
12	4 46	15	1 35	92 0	1388.0	4 08	77 1	$6\frac{7}{16}$	$4\frac{13}{16}$	$1\frac{9}{16}$	$1\frac{3}{16}$

respectively, tangent, radii and degree of curvature. Column 8 gives length of cord CF, Fig. 44. Columns 9 and 10 give respectively middle and quarter ordinates when turnout is laid from a straight track. Columns 11 and 12 are used in obtaining the ordinates of the cord CF when the turnout is laid from a curve. The change in the ordinates is approximately in proportion to the degree of curve of the main track. A rate of change is calculated per degree of curve of main track. To calculate the ordinates: take from the table, opposite the number of the frog used, the change in middle and quarter ordinates; multiply each of these fractions by the degree of the main track curve. If the turnout is with the curve add the products respectively to the middle and quarter ordinates of a turnout from a straight track of the same frog number. If against the curve two cases arise; first, when the turnout curve is the sharper, it is then curved the opposite direction from the main track; the ordinates are obtained by substracting the products from the ordinates of a turnout from a straight track; second, when the main line has the sharper curve the turnout then curves the same direction as the main line; the ordinates are obtained by reversing the first case by subtracting the ordinates from the products. (See paragraph 17.) Columns 13, 14 and 15 give respectively distance from head block to middle frog point in three throw switches, frog angles and their frog numbers.

TABLE FOR "POINT LEADS."

6. Table 2 is calculated for a split switch fifteen feet long, laid tangent to the turnout curve at its heel. The angle of the bend is 1 degree 35 minutes or about the proportion of $\frac{1}{2}$ in 18, and is placed about ten inches back of the points. The spread at the heel is five and

a quarter inches. The ordinates of the outside rail is not the same for all frog numbers as in stub switches.

FROGS.

7. A frog is a contrivance for allowing the wheels of a car to cross a rail.

Fig. 47 is an outline diagram of a frog. The triangle, A C E, is tongue. C E is the heel of the tongue. The channel at K is the mouth. Its narrow part, F H, is the throat. The wings, F G, and H I, support the treads of the wheels from the point, B, to the throat. L M is the heel of the frog. The angle is the divergence of the lines, A C and A E. The intersection of the lines at A is the true point of the frog. As this point is too weak for service, it is rounded off where the tongue is about one-half inch wide. The frog num-

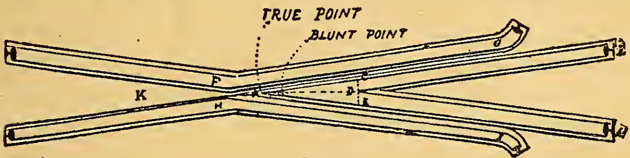


FIG. 47.

ber is the ratio of the base, C E, to the perpendicular, A D, the length of the point. Thus, if the length, A D, be 7, 9 or 10 times C E, the frog is called a No. 7, 9 or 10 frog. The angle of the frog is determined approximately by dividing 57 3-10 degrees by the number of the frog. To get the number of a frog one of the following ways may be used:

1. Take a stick of any length, say six inches; try this near the heel of the frog where the spread of the frog equals the length of the stick; then from this point measure with the stick to the theoretical point of the frog; if it is seven times the length of the stick it will be a number seven; if eight times, a number eight, etc.

2. Measure with a rule and find where the spread is four inches; mark this point; then get where it is five inches; also mark this; then the length in inches from where it is four to five inches measured along the rail will be the number of the frog.

3. Add the spread between the gauge lines at the heel to the spread at toe in inches and divide this into total length of frog in inches; the result will be the number.

4. Divide the spread between gauge lines at the heel of frog in inches into length along the rail from heel to theoretical point in inches; result will be the number.

5. Divide the spread between gauge lines at toe in inches into length along rail from toe to theoretical point in inches; the result will be the number.

Crossing frogs are used where one track crosses another. They are generally supported by long ties for the smaller angles, and heavy framed timbers for the larger angles. The nearer the angle approaches 90 degrees the more difficult they are to maintain, owing to the wheels dropping into the space left for the crossing track. Where one road is double-tracked, the frogs are difficult to keep in line, owing to the tracks of the double line often creeping in opposite directions.

In order to make a continuous main line rail, spring frogs are introduced. These are right and left handed. To determine whether right or left, stand at the toe and face the heel; if the loose rail moves towards the left it is left-handed; if towards the right, it is right-handed.

LAYING FROGS IN TRACK.

8. When putting frogs into a track care should be taken to have them in a true line and level with

the track rails which are connected to them. The gauge rail, opposite the frog, should be put to a perfect gauge for the full length of the frog. In sharp turnouts, when all of the track at the frog and running each way from it is put to a perfect gauge, there is left opposite the frog an ugly looking kink. This is caused by the rail of the frog being necessarily straight. It does not correspond with the curve line which runs each way from the frog. This can be remedied without injuring the track by spiking the curve track enough wide gauge to have it line true with the track at the frog. To have a perfect gauge along the frog, the gauge should be tried at each end of the frog and again about six inches back of the point of frog. When long frogs are used and there is very little curve in switch lead, the track can be spiked to a proper gauge and the kink, spoken of as showing at the frog, will not be perceptible. Foremen should see that frogs are not allowed to fill up with ice or snow in the winter season, and when foot guards for the protection of trainmen are provided, section foremen should see that they are always kept properly in place to prevent any liability of accident.

LENGTH OF FROGS.

9. Long frogs and long switch leads are the best where it is practicable to use them; the rails in short switch leads soon wear out. If the switch lead is long, the saving effected in the wear of the rails and rolling stock more than compensates for the loss of the extra amount of steel in the long frog when worn out. A valuable feature in a frog is to have it of such a length that very little cutting of rails is necessary when putting in a new switch. When full length rails can be used in a switch it saves time, labor and material.

GUARD RAILS.

10. The guard rail at frogs is used to prevent the car and locomotive wheels from crossing the point of the frog on the wrong side when trains are passing through the switch. The length and shape of a guard rail adopted as the standard should be used with all frogs in service on the same road. No guard rail should be less than ten feet in length, nor over twenty; fifteen feet is the average. Enough of the middle of the guard rail should be spiked down parallel with the track rail, opposite the point of the frog, to cover the distance from where the side wings separate at the throat of the frog, back to the frog point. This is an ample protection. The guard rail may be secured by spiking it to the ties, and by passing a bolt through the guard rail and track rail at each side of that part which is parallel with the track rail, leaving between the two rails a wheel channel This makes it unnecessary to use braces except as additional precaution. Iron spools or washers may be used on the bolts between the webs of the guard and track rails, to regulate the width of the wheel channel, which should never be more than two inches on a standard gauge track. Also clamps may be used; these are of great advantage, especially when a guard rail fills with snow.

The extreme ends of the guard rail should be spiked to the ties at a distance of four inches from the track rail. This will give the wheels an easy and gradual approach to the narrower space where the rails are parallel. Guard rails should not be sprung to place with the track spikes but should be bent to the proper shape before being laid. A good form of guard rail is shown in Fig. 48.

When guard rails are made in the company's shops their ends should be heated and hammered down to

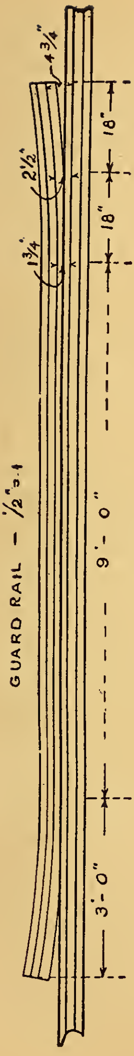


FIG. 48.

form a gradual approach or slanting surface from the base of the rail, where it rests on the ties, to the top. This would prevent brake beams, chains, or snow plows, etc., from catching on the end of the guard rail and tearing it out of place. It would be well to take the same precaution with the ends of guard rails which cross bridges or go around curves inside the rails on main track.

IF THERE IS NO STANDARD.

11. Where there is no standard guard rail used on a railroad, and the track foremen have to provide the guard rails wanted, when they put in a new switch, the piece of rail which is cut from a full length rail to let in the frog will do to make a guard rail, and when long enough should always be used for a guard rail in preference to cutting another good rail. Very long guard rails are a waste of material and fastenings, which could be put to better use at some place else on the road. Long guard rails are always difficult to keep in place, especially on sharp turnouts, because where ten, twelve or fifteen feet of guard rail is spiked down parallel with the track rail, as is often the case, the drivers of an engine or the wheels of a car truck are all at

one time in the narrow wheel channel, and cannot curve properly. They therefore wrench and twist the guard rail, while the wheel base is held in a straight line. This wears the rolling stock, besides making it more difficult for an engine to pull a train through the switch. The width of the wheel channel between the guard rail and track rail should never be wider than the wheel channel through the frog. If the wheel channel between the guard rail and track rail is one-quarter inch or or more wider than the frog channel, car wheels with sharp flanges are very apt to climb the frog point, and run off the track, especially if the guard rail side of the track is the highest. The frog point always shows wear on whichever side the guard rail is too wide.

Another error in the usual practice is to place the guard rail so that its center will come even with the point of the frog. The effect of this, especially with 15-foot guard rails, is to jerk trailing wheels against the end of the frog wing rails, and if the gauge of track happens to be wide the frog bolts will be broken. Even if the track is in proper gauge the end of the guard rail projecting beyond the end of the wing of the frog will throw worn flanged wheels (because of their greater lateral play) against the frog wing, thus subjecting an already weak flange to the danger of being broken, whereas if the projecting guard rail did not alter the course of the wheel it would enter the frog without a shock. The province of a guard rail is to guide the facing wheel flange safely past the point of the frog, and where the wheel has passed this point, be it but one inch, it has no further use for a guard rail. Therefore about two-thirds of guard rail should be ahead of the point of frog, and in no case should the rear end of it pass the end of the frog wing at a point

three feet from each end, so that when laid to place the space between main rail and end of guard rail will be about four inches. The ends of guard rails should not be curved, but bent at the point mentioned, which may be done by first heating the rail. The usual practice is to put a short curve in the ends of guard rails, but the incline thus made is too abrupt and is liable to break wheel flanges.

SWITCH TIMBERS.

12. As there is considerable difference in the standards for bills of switch timbers on the different railroads, the following rules will be useful to track foremen:

Rule—To ascertain the number of pieces needed for any switch lead, find the distance from the head block to the point where the last long tie will be used behind the frog. Reduce this distance to inches, and divide it by the number of inches from the center of each tie to that of the next one. This will give the number of ties wanted.

Example—Distance from the head block to the last long tie behind the frog, 55 feet; reduce to inches, 660 inches; distance from center to center of ties, 20 inches; number of ties required, 33.

The first three of these ties next the head block may be common long oak cross ties, and as 9 feet is the shortest piece sawed square for a switch tie, and 14 feet the longest for a single throw switch, the other 30 pieces may be divided up, when ordering the different lumber lengths, as follows:

5 pieces, 9 feet long;	5 pieces, 12 feet long.
5 pieces, 10 feet long;	5 pieces, 13 feet long.
5 pieces, 11 feet long;	5 pieces, 14 feet long.

When odd lumber lengths of switch timbers are not furnished, then order double the quantity, 10, 12

and 14 foot pieces. In large yards where there is very heavy traffic, switch timbers should not be laid more than 8 or 9 inches apart. A switch that is well put in, with timbers under it 8 inches apart, will wear out the rails without needing any repairs in the surface; but when ordering switch timbers foremen should always be governed by whatever standard is in force on the road.

TO CUT SWITCH TIES THE PROPER LENGTH.

13. Rule—Measure the length of the tie next the head block and also the length of the last tie behind the frog. Find the difference in inches between the lengths of the two ties, divide this amount by the number of ties in the switch lead, and the quotient should be the increase in length per tie from the head block towards the frog, to have the ties line evenly on both sides of the track.

Example—We will suppose the tie next to the head block to be 8 feet 6 inches, or 102 inches in length, and the last tie behind the frog, 14 feet or 168 inches in length. The difference in the lengths of these two ties is 5 feet 6 inches, or 66 inches; dividing by 33, the number of ties, gives 2 inches as the amount that each tie must be longer than the last.

Section foremen will find this rule valuable in many cases, especially when putting in a cross-over from one track to another. There is nothing gained by having switch ties project beyond the proper line of track. They cause trouble in raising track, are unsightly, and labor is only wasted in tamping up the long ends. The switch ties may be cut off the proper length and numbered with chalk, and the line side marked for the rail flange before being put in the track. The work can be done in that way quicker and better, and the un-

necessary labor of digging out for the tamping up long ends can be dispensed with.

TAMPING SWITCH TIES.

14. When a switch track has been raised to surface the track at that place, the switch ties under the frog and main track rail, should be tamped up first. The long ends of switch ties should be tamped up last and then not as solid as those under the frog. Tamping bars should be used in tamping up a switch, and special care should be taken to make the ties as solid as possible under the frog. A switch is all the better if the frog is a shade higher than the balance of the switch. Head blocks should also be a little higher; a quarter of an inch higher than the level of the track rails will do no harm, and will soon come down to level on a stub switch. If the outer ends of switch ties are tamped up first, unless the timbers are very large, they will sag down in the center and the ends turn up, especially if a train is allowed to pass over the switch before the ties are tamped throughout their length.

A set of switch timbers may be put into a mud track very quickly, and with little or no tamping, by the following method. Remove all the old timbers except a few to support the track rails. Raise the rails on the supporting ties about a quarter of an inch higher than the track surface, and level them with a spirit level. Clear away a bed for the timbers equal to their depth, and spread a little loose dirt on it, then pull in the timbers, keeping their upper surface close up to the rails and each timber level throughout its length until it is in place.

PUTTING IN THREE-THROW SWITCHES.

15. The length of switch ties in a three-throw switch is found by doubling the set for a single turnout, and subtracting the length of the standard cross-

tie. When putting them in the track, measure the length of each tie and draw a chalk line across the middle; mark also the middle of the gauge. Lay the gauge on the main track, and as each tie is put under the track, see that the chalk mark across the middle of the tie comes directly under the middle of the gauge of the main track. The proper angle, number and distance from the head block of the middle frog is given in table No. 1. The number of the middle or crotch frog is found by multiplying the number of the side frogs by the decimal .707, or by adding the numbers of the two side frogs together and divide by 3, and its

FIG. 49.

distance from the head block is found by dividing the radius by twice the middle frog number, and subtracting the length of switch rail. If there is no frog corresponding to the number of the crotch frog at hand, select one as nearly like it as possible, and calculate its distance ahead of the head block. The line of the lead rails will then be a compound curve.

DERAILING SWITCHES.

16. Fig 49 illustrates a method of derailing cars and is used in cases where extra precautions are required to prevent cars from accidentally running out of the siding upon the main track.

It consists of a head block, a low switch stand with a connecting rod attached to the outside rail C D, near the end of the curve on the siding, and a head chair, E, to receive the ends of the rail, B and C. Connection

is broken by throwing the switch which moves the moving rail, C D, inward. This guides the derailed car away from the main track. The bolts should be placed on the rail, C D, with the nuts inside so that derailed wheels will not cut them off. When putting in this derailing switch, drive a row of spikes against the inside flange of the rail, C D, when set for derailing; and place rail braces on the outside to support and keep the rail in place, when set for the side track. It is good policy to use sound oak ties, spaced not more than eight inches apart under the moving rail. It presents a smoother surface for the derailed cars than ties spaced the ordinary way, and prevents the wheels from sinking between them.

This switch has less parts and is more economical than a derailing switch with two moving rails connected with rods. When properly secured with a hinge joint or pivot, and working on a solid plate throughout its length, a much shorter sliding rail can be used. A point rail can be used, and the end of the rail at B can be slightly turned outward, but there is no advantage in its use except to make it work lighter when automatic connection is made with the main track switch.

When setting up switch-stand, have the target show danger, when the switch is set for derailing.

TURNOUTS FROM CURVES.

17. In turnouts from curves, the lead distance is practically the same as turnouts from a straight track. The degree of curve of the turnout is approximately increased by the degree of the main track curve, when the turnout is with the curve; and decreased the degree of the main track curve, when the turnout is against the curve. In turnouts against curves, when the degree of the main track curve is the same as the turnout

curve corresponding to the frog, the lead will be straight; when greater, the turnout curve will deflect the same direction as the main track curve. As curves for the ordinary frog numbers are sharp, avoid as much as possible turnouts from the inside of the curve.

In turnouts from curves the ordinates for a straight track will be increased a certain rate per degree of main track curve, when the turnout is laid with the curve; and decreased the same rate per degree when the turnout is laid against the curve.

EXAMPLES:—A turnout with a curve; degree of main track curve, 2 degrees; frog No. 9, table 1. Here degree of curve of turnout = 2 deg. + 7 deg. 31 m. = 9 deg. 31 m. Middle ordinate = 15-16 × 2 = 1 7/8 inches; added to 7 inches = 8 7/8 inches. Quarter ordinate = 11-16 × 2 = 1 3/8 inches; added to 5 1/4 inches = 6 5/8 inches. Middle ordinate 8 7/8 inches; quarter ordinate 6 5/8 inches.

EXAMPLE:—A turnout against a curve; degree of main track curve 4 deg., frog No. 8, table 2. Here degree of turnout = 9 deg. 31 m.—4 deg. = 5 deg. 31 m. Middle ordinate = 3/4 × 4 = 3 inches; subtracted from 7 inches = 4 inches. Quarter ordinate = 9-16 × 4 = 2 1/4 inches; subtracted from 5 1/4 inches = 3 inches. Middle ordinate 4 inches; quarter ordinate, 3 inches.

EXAMPLE:—A turnout against a curve; degree of main track curve 8 deg.; frog No. 10, table 2. Here degree of turnout = 8 deg. —6 deg. 13 m = 1 deg. 47 m. The turnout will curve the same direction as the main track curve. Middle ordinate = 111-64 inches × 8 = 9 3/8 inches; 9 3/8 inches —7 1/2 inches = 1 7/8 in. Quarter ordinate = 7/8 inches × 8 = 7 inches; 7 inches—5 7-11 inches—1 9-16 inches. Middle ordinate, 1 7/8 inches. Quarter ordinate, 1 9-16 inches.

TO REACH A SIDE TRACK WITH A REVERSE CURVE.

18. The simplest and most economical method for laying out a side track, along which buildings are located, is to continue the lead curve back of the frog to a point which would be midway between the tracks if they paralleled each other. Then reverse the curve

and join it with the tangent on side track at a point the same distance from reversing point as the switch point is in the opposite direction, as shown in Fig. 50.

Rule—When laying out the side track parallel with the main track, continue setting center stakes as if for a tangent from A to B, Fig. 50, making the latter point come at right angles with C, which is the point of switch already located in main track.

Then measure accurately the distance between the stakes, B and C, and set a stake at D, midway between

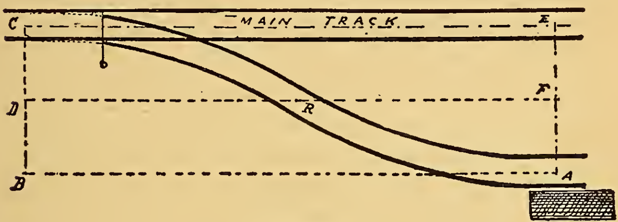


FIG. 50.

them. The point, R, may be found by running a line of stakes from D to F, parallel with main track.

After you have laid the switch and side track curve as far as R, then measure the distance, R F, making it equal to the distance, R D, and set the stake at right angles with F at A, which will mark the end of curve on the side track. A stake may be set at E, for convenience in locating the point, F, and the angle F A, or C D, may be squared fairly well by using a common track gauge, laid across the rails at C or E, on the main track. There is a great deal of good track room wasted, where side tracks are put in with a long tangent behind the frog and the method here illustrated has advantages where land is valuable, and it also economizes material. But the use of curves above 6 degrees is not recommended, because the track is not as

safe, is more difficult to keep in repair, and the rails wear out much sooner on sharp curves.

ROUND HOUSE TRACKS.

19. To locate the frog point for round house tracks, find the distance between and including the tops of the two adjoining rails in two stalls of the house. Any point where you have laid the rails will do to measure this distance; near the house doors is a good place. We will suppose this distance to be twelve feet.

The frogs about to be used are four feet or 48 inches in length from point to heel, and the extreme width of the heel is, say, eight inches. By dividing the length, 48 inches, by the width of the heel, you find the frog to be a number six, as the rails deflect from each other one inch in six, or one foot in six feet, two feet in twelve, four feet in twenty-four, eight feet in forty-eight, and twelve feet in a distance of seventy-two, etc.

This shows that the point of frog must be located seventy-two feet ahead from the point where measurements were taken, at which place the rails were twelve feet apart. But to locate the frog point accurately, two lines should be stretched along the gauge side of the two-track rails running out of adjoining stalls. Carry them in a straight line to the turntable. This will cause them to cross each other where the frog point should be located. Stretch the lines tight and lay the frog down under them and spike it to the ties.

In order to get the true point of a frog the lines should touch the gauge side of it throughout its full length, and the correct point is where the lines cross each other, not the end of the frog point. After the frog is located the rail connections behind it may be made, and if the other frogs are of the same angle as the first one, they should all be placed the same distance from the turntable and spiked accurately to

gauge. But if the frogs are of different angles (which should be the case) they will need to be laid at different distances from the turntable proportionate to their angles.

ANOTHER METHOD.

20. The frogs which lead from the turntable into the round house may also be located in the following manner: Draw two cords along the gauge side of the nearest rails in two adjoining stalls and cross the lines before reaching the turntable. Then stretch the cords tight, holding the end of each at the middle of one of the track rails on the center of the turntable. Swing the turntable into line with one of the stalls, and while it is held in this position mark the place where the two lines cross each other. The place so marked will be the point of your first frog. The other frogs will all be right if placed the same distance from the turntable as the first one, and spiked accurately to gauge.

CROSS-OVER TRACKS.

21. To put in a cross-over from one track to another where the work has not been laid out by an engineer:

Rule—Put in the first frog and switch lead complete on one track. Then sight a straight line along the gauge rail from opposite the point of frog, which you have just put in track, to the nearest rail of the adjoining track. Where the line crosses the rail is where the point of the next frog ought to be located to complete the cross-over if both frogs are of the same angle.

Another method when the same number frogs are used: Take the difference between the gauge lines of the inside rails and the gauge of track, multiply the remainder by the frog number, and the result will be

the distance measured along the track, Fig 51, as D C, or A B.

EXAMPLE:—Distance between gage lines of middle rails, 7 ft. Frog No. 9. Distance between frog points equals 7 ft. less 4 ft. 8 inches. = 2 ft. 3½ inches; 2 ft. 3½ inches × 9 = 20 ft. 7½ inches.

To find the distance between frog points in a cross-over: For 12-foot centers multiply 2.58 by the number of the frog. If the distance between centers is less than 12 feet, subtract the difference from 2.58; if more, add the difference. Thus: Find distance between frog points on a No. 10 cross-over, distance be-

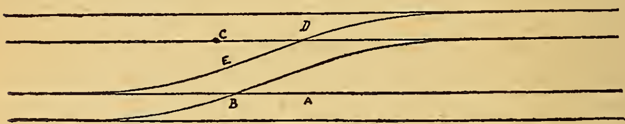


FIG. 51.

tween track centers is 12 feet; 2.58x10, equals 25.8 feet.

If the center distance is 11 feet, we have as follows: Eleven feet is one less than 12 feet; hence we subtract 1 from 2.58 and we have 1.58; if a No. 10 cross-over is to be put in we have: 1.58x10, or 15.8. If the center distance was 13 feet we would have 3.58x10, or 35.8. These measurements are made on the main line rail.

Another method, which is particularly important when the frogs used in the cross-over are of different angles, is as follows: Add the numbers of the two frogs together and divide by two. The result is the average number of frog for cross-over; and multiply this with the distance between gauge lines of inside rails, less the gauge; or, where the distance between centers of two tracks are used, subtract twice the gauge

from this distance and multiply with average number of frog.

EXAMPLE: — Distance between centers of two tracks is 12 ft. It is desired to put in a cross-over, using a No. 10 and No. 8 frog. Proved according to rule: $10+8=18$ divided by 2 equals nine. Then $2.58 \times 9 = 23.22$ ft.

TABLE OF DISTANCES BETWEEN FROG POINTS IN CROSS-OVER TRACKS.

22. The following table shows the distance between frog points diagonally in any cross-over track put in with the frogs mentioned in the table, for distances between tracks of 7 to 15 feet. Where the distance between two tracks is greater than 15 feet, foremen can calculate the distance between the frog points by the rules preceding this table:

Numbers of Frogs.	DISTANCE BETWEEN TRACKS.								
	7 ft.	8 ft.	9 ft.	10 ft.	11 ft.	12 ft.	13 ft.	14 ft.	15 ft.
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft in.
1 to 5..........	11 6	16 6	21 6	26 6	31 6	36 6	41 6	46	50 6
1 to 6..........	13 6	19 9	25 9	31 9	38	44	50	56	62
1 to 7..........	16	23	30	37	44	51	58	65	72
1 to 8..........	18 4	26 4	34 4	42 4	50 4	58 4	66 4	74 4	82 4
1 to 9..........	20 8	29 8	38 8	47 8	56 8	65 8	74 8	83 8	92 8
1 to 10..........	23	33	43	53	63	73	83	93	103
1 to 11..........	25 3	36 3	47 3	58 3	69 3	80 3	91 3	102 3	113 3
1 to 12..........	27 6	39 6	51 6	63 6	75 6	87 6	99 6	111 6	123 6

As the above table gives the distance in feet from a point on the gauge rail opposite the point of the first frog to the point of the frog in the next switch of the cross-over track, the length of the second frog from point to heel must be deducted from the distance given, when preparing the rails which cross between the tracks.

A reverse curve can be made longer in the cross-over between tracks when they are very far apart. and there is not room to put it in the regular way.

PARALLEL TRACKS.

23. Where a track runs from a main track and it is used to throw off switches from, and if the track from such switches is to run parallel to the main track, inexperienced foremen find it difficult to locate the frog for a new track so as to have straight track behind it. The place for the pcint of frog for a new track can be easily located by the following method:

Rule—Sight a line with stakes where you find the outside of the rail should come back of the frog on

FIG. 52.

your intended track, and parallel to the main track, or the nearest track which runs in the same direction. Then with stakes carry the line perfectly straight until it crosses the first rail of the ladder track. This is where the frog point should be placed for the new track.

The above rule will always work well where the two tracks separate behind the frog at an angle corresponding to the angle of the frog, but should it be necessary to maintain two tracks, running from a switch, which diverge at an angle that will not suit the frogs you intended to use, you can ascertain by the method shown in the diagram, Fig. 52, what kind of a frog will be needed.

HOW TO ASCERTAIN THE KIND OF FROG NEEDED.

24. The lines in diagram represent the rails of two tracks. Measure across between the track rails at the points marked A and B, each of which is an equal distance from C, which marks where the rails cross or

point of intersection; then measure the distance, C B. Now divide the distance, C B, by the distance, A B, and the result will be the number of the frog required. Suppose the distance, A B, is twelve inches, and the distance, C B, nine feet; it would require a one to nine frog, or as it is sometimes called, a number nine frog. The distance, A B, may be measured where the rails or lines are only six or eight inches apart, but the result will always be the same in proportion to the distance from C to B. Where tracks are to run parallel with each other, it is best to gauge the distance they are to be apart by measuring from the nearest rail of a permanent track adjoining, if in good line, or from the center of the main track in yards.

In ladder tracks the distance between frog points, where they are all of the same number, is equal to the distance between track centers multiplied by the frog number.

SPUR TRACKS.

25. Spur tracks should be laid with a view to avoiding any extra switching. Always put in a switch on that end of the spur track which is in the direction in which the loaded cars are to be hauled. This matter does not always receive the attention it deserves. It is much easier to throw empty cars back upon a spur track than to head an engine in after the loads, and push them ahead to the nearest station to be switched there again. Much valuable time could be saved if all spur sidings could be dispensed with. Time is money in all the departments of a railroad, and those trackmen who supervise the laying of any new tracks, especially in yards, should lay all tracks with a view to the most efficient handling of cars. Help the train department all you can. Put a switch at both ends of a track whenever it can be done at a reasonable cost.

CHAPTER XIX.—USE AND CARE OF TRACK TOOLS.

TIDY TOOL HOUSES.

1. Tidy Tool Houses.—Most railways furnish tool houses with ample room in them for a hand car and all the tools necessary for a section gang, and with a little pains on our part we can arrange them so that each tool may have its own place, and kept there when not in use. By taking a look at a foreman's tool house a fair idea of his ability may be gained. If he has a tidy and well arranged tool house, with the hand car and tools all in good working order, you can rest assured that there is some well-kept track not far away.

Foremen are expected to send their tools to the shops to be repaired, or to be replaced by new ones, whenever necessary, so there is seldom any excuse for having tools on hand which are not in working order.

There is probably a difference of opinion as to just how each tool should be used, but it is admitted that there should be an individual system of use and care of track tools, and that the best should be given.

THE PRINCIPAL TOOLS AND IMPLEMENTS.

2. The Axe.—The first thing needed for it is a handle, which should be snugly fitted to it, and firmly wedged in. Next it should be ground sharp, and kept in that condition, for when an axe is needed it should be sharp; it should not be used for anything but chopping or splitting.

3. Adzes.—It takes some practice to learn to use an

adze properly, and leave the ties smoothly adzed. In adzing down old ties, adze deep enough so that the edge of the adze will go beneath the flange of rail and thus avoid dulling the adze. When adzing ties on curves, to turn rails in, great care should be exercised, so as to adze ties uniformly and a proper depth, always keeping a lookout for stub spikes, or anything which will dull adze unnecessarily. The adze should not be used as a hammer, nor for anything but adzing. A handle is very easily adjusted to this tool, but is easily broken if not handled rightly.

4. Brooms.—The proper and diligent use of them in the tool house and on the hand car floor, on and around depot platforms and other buildings, which the section men have to keep clean, helps their appearance wonderfully. Brooms are often handy for cleaning off ties when gauging track or turning in rails.

5. Hand Cars.—Oil boxes should be frequently repacked, as the packing soon becomes filled with sand. All boxings kept fitted snug; when they become worn, file or grind them down. Keep all keys tight, as well as all bolts and nuts. Do not let cogs mash deep enough to grind. See that driving arm is not too short or too long so as to throw one end of walking beam too high and the other too low. Drop a little oil on all the bearings often. Do not use much at a time, but apply often. Care should be exercised when putting car on and off the track. A little pains should be taken to instruct men in pumping a car so that they pump steady and together, and in going up grade or against the wind to pump on the top stroke as well as the down. Keep the car going at a brisk rate, for it is easier to keep them going that way than it is to pump them when the speed gets down too low.

Hand cars are in universal use, and a car which will give good service on an American road will be equally desirable and useful on any foreign railroad. To be desirable a hand car should be light, speedy, strong, durable, and of a simple construction, so that the section men can perform minor repairs without having to send to shop. With these qualities it will pay for itself in a year in time saved and useful work performed.

Several manufacturers make a specialty of building improved hand cars, any of which are preferable to the

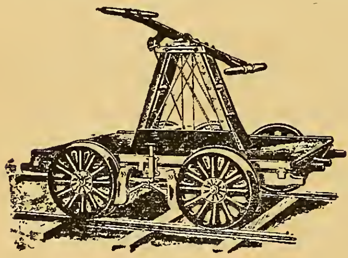


FIG. 53.

"home made" ones which come from the railway shop. The best known car in all parts of the United States, and one in most extended use is the Sheffield. Fig. 53 shows a perspective view of the No. 1 Standard Section Hand Car for standard gauge, having a platform six feet long by four feet four inches wide. The wheels are made either with wooden centers or all steel, but the present tendency is toward steel wheels, the whole car weighing only 510 pounds.

All Sheffield cars are equipped with machine-cut gears, which insures exact fit of the teeth of the pinion and drive wheel, with a consequent easy and smooth motion, saving both time and labor in running over section. Another important improvement is the method of fastening the gear wheels to their axles, shown in Fig. 54, which does away with

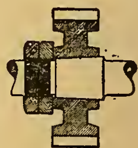


FIG. 54.

the usual key entirely, and they can be given any de-

gree of tightness by screwing up nut, which forces the hollow cone of wheel hub on to the solid cone of shaft, while the wheel remains perfectly concentric with shaft, insuring absolutely correct rotary motion. This is particularly important with the pinion gear, as a slight deflection, or eccentricity will bind on the drive wheel and make the car hard running. In addition to the above mentioned No. 1 Standard Section Hand Car, some seven or eight modified forms are made by the same company, thus supplying various wants of railway companies, but all possess the above mentioned desirable features.

What is here mentioned of the hand cars applies also to a certain extent to velocipedes; they are made with three or four wheels, arranged to be propelled by hand as well as driven by mechanical motors. This latter mode of operation has gained in favor of late years and is particularly advantageous for roadmasters who have to cover long distances, or for inspection trips where considerable speed is required, and where the working of the levers of a hand car would interfere with the view of the inspectors. For short distances the one-man Sheffield Velocipede Car cannot be excelled for speed and easy running.

6. Claw Bars.—There is nothing which will cause more annoyance than a poor claw bar, one that the claws are too far apart at toe or too close together, neck not properly bent, heel out of proportion to claws, and so on. Most of these things can be remedied at shops. When they are sent in to be remedied a letter and a print should be sent along if possible, showing what changes should be made. A good many of the claw bars now in use would be more valuable to the company in the scrap pile than anywhere else.

7. Cross Cut Saws.—Strict attention should be paid to filing and setting of them. They should be carried on the car and kept in tool house in such position that the teeth will not come in contact with other metal tools. Men should stand squarely opposite each other when sawing and drag the saw toward him, but never try to push the saw from him. A saw in good running order does not need any crowding.

8. Cold Chisels.—A full complement of these should always be kept on hand. It is the custom when using a chisel to stick any kind of a hard wood piece in for a handle, but it pays to fit good handles to chisels, as well as other tools, so you will not have to stop to drive handles in while cutting a rail, and it is easier to hold a chisel rightly if it has a good straight handle in. A great many chisels are spoiled by not holding properly. If a chisel has good temper and is not broken too badly or is very dull it is better to grind them down than to send them to the shop; but if they cannot be ground down profitably, they sould be sent to the shop at once.

9. Track Gauge.—The gauge should be made to serve a better purpose than only to mark the standard distance between the rails. A wooden gauge might do as well when ends are well bound with iron, but a metal gauge is better. There should be a fork on the one end to prevent gauge from falling on its side when spiking, and also to square the gauge across the track. This end should be fastened solid, either welded or screwed and riveted to the end of a wrought iron pipe. On the other end of this pipe being the single end of the gauge, the lug should be adjustable; it should screw up tight on the pipe when standard gauge was desired, and if thread was 16 to 1 inch turn the lug

once for every degree of curve, and if thread was 8 to 1 inch turn the lug once for every two degrees to widen gauge on curves. A small thumb screw through the adjustable lug, with a narrow seat planed on pipe for same, would hold the lug in place, and this screw seat would also hold oil to keep thread from rusting and turning hard. The lugs should be the same size on both ends—$1\frac{3}{4}$ inches wide and $1\frac{3}{8}$ inches deep. This would fill the bill under all circumstances and would be simple, strong and no tender parts to break; would adjust to widen gauge on curves; the width of the lugs is standard guard rail distance, the depth of the lugs will show if blocks in switches are clear of wheel flanges, allowing one-fourth inch extra as flanges on wheels are generally $1\frac{1}{8}$ inches deep; the wide lugs on double end of gauge would fit snugly between wing rail and point of frog and stay there, while the single end would show where to set the guard rail, regardless how wide the track was. This gauge would pay for itself in the saving of untimely wear of frog points alone, besides other service it would do while gauging track on curves.

10. Lining Bars.—Most of the bars in use are iron and are too heavy. A steel bar weighing about twenty pounds, with chisel point on square or bottom end of bar, and sharp pointed at small end, would be about the right thing. Lining track is probably one of the most difficult things a foreman has to do if he wants his track in perfect line. Where track has just been raised, take only enough men and bars to move track easily. Don't let men stick the bars in the ground at too great an angle; if they do they will raise the track when they throw it over, and if the ballast is sandy some of it will run under the ties and spoil the surface of track. When lining track where it is hard to move, bars should be

stuck firmly in the ground before heaving on them, for if one bar slips all the other men have to wait while that one is being replaced. Men must always pull together, and always be ready when the word is given; the foreman should keep as far back as he can, to see well. To avoid putting swings in the track, some of the little defects can be taken out at short range.

11. Lanterns.—They should always be kept in perfect order, for you never know at what moment you will need them, and you are always in a hurry when you do. The lanterns usually furnished are good to use for signals, but give little light to work by. A couple of engineer's torches will give more light to work by than a dozen lanterns. Every trackman should know all lamp signals thoroughly, and when placing danger signals or slow signals, care should be taken to place them in plain view of an approaching train, and be sure to have them out the full distance required by your book of rules. If you err at all, be on the safe side. It is a short job to place signals, and serious accidents will be prevented often if they are put out properly. If you have any doubt about the stability of a piece of track, don't hesitate to use your signals. Be on the safe side. Lanterns, after being used, should have the oil taken out and put back in the oil can. Clean the globes, trim the wick, and set them in a safe place. If lanterns set a long time without use the wicks should be changed, or they will not burn well. When putting out lanterns as danger or slow signals, be sure they are in good trim and plenty of oil. Signal oil gets too thick if it stands very long in small cans. In case it does not burn good, add coal oil to it. A few extra globes should always be kept on hand.

12. Spike Hammers.—About eight pounds is the right weight. Select the straightest handle for this and

fit it snugly and wedge it good and tight. If the eye is not straight in hammer, which is often the case, take a rat-tail file and file it out as near straight as possible, for a poorly hung hammer will always be an annoyance. If face of hammer gets too rounding, file or grind it down. The next thing is to know how to drive a spike properly with it. Stand at side of rail to spike and start the spike perpendicular; never allow the spike to slant under the rail. A spike may be leaned a little from you when started, but the second blow should straighten it up. Stand with heels close together, and use full length of handle, and give long, swinging strokes, when spiking.

13. Shovels.—The blade should be ten inches wide and twelve inches long and handle thirty inches and necessarily must have good material in them and be well made. About seven pounds is a good weight for shovels. It is not every man who can make a good shoveler, although it looks easy enough at first glance. It takes considerable practice to make a good shoveler, and it needs experience to tamp ties properly, but after once learning it is easy enough and nice work. In dressing in ballast a man needs to be quick and handy with a shovel and a good eye to make the work uniform and look neat; but the most important part is in tamping where the ballast is sandy; centers are liable to be humped if we are not careful. Be sure and tamp well under the rail. A man should learn to shovel left as well as right handed. When a shovel gets weak in the handle or worn short lay it away for cutting weeds and take a new one for tamping or casting dirt. If there is any mud sticking to shovels clean them off when you quit work.

Wherever there are posts, telegraph poles, cross-

ings, signs, or whistling posts to be set or gravel to be loaded on cars, long-handled, round-pointed shovels are the best.

Wherever there is cinders, coal or sawdust to be handled the scoops should be used, for time will be wasted trying to handle it with small shovels.

A shovel should not be left out in the rain when not in use, as the wood in the handle swells so as to turn the edges of the straps out and split the handle into slivers or burst the rivets. When a shovel is left exposed to the hot rays of the sun, when not in use, the grip on the handle checks, and we all know how disagreeable it is to have the pieces rattling in your hand when shoveling; besides, the untimely breakage of the handle making the shovel of no further use. To prevent this all you have to do when leaving your shovel any length of time, lay it down and cover the grip with a handful of dirt or gravel or anything at all to shade it, and you will see the small trouble will be well rewarded in always having a good handle on your shovel. The shovel should never be used instead of a bar for holding up ties when spiking, nor as a bar or pick for breaking loose rocks and dirt, nor as a pick for putting in ties in track, nor as a mattock for cutting roots and stumps, nor as an ax for cutting brush and logs, and a man that does not use his shovel in this manner knows all the better how to use it for the purpose it is intended.

14. Scythes.—The brush hook comes in for more abuse than should by right be inflicted. In cutting brush on rocky dumps or on slope of cuts the general practice by inexperienced men is to slash right and left in rock and mud, and if the brush is too heavy for the hook, still bang away until handle breaks or until

pieces break out in the edge, at times so bad as to make the hook of no further use. Where such is the practice it should be stopped, and the hook used for small brush and the axe for big brush.

The brush scythe is sometimes used for small brush, and comes in for the same abuse in proportion as the hook. It is best to dispense with both of them, and, instead, used a short sickle, about five inches long, on the blade, with a handle affording a good hold, to prevent the hand from slipping. Having tried this for small brush, anything under one inch in diameter, and the axe for the bigger brush, it will be found that a man can nearly double the work done with the brush hook or scythe.

The grass scythe is like all other track tools abused, along with grass, all sorts of rubbish, and even pieces of old ties are cut, and after using a new scythe for a few days, it is twisted up like a raw poplar board, after being exposed to the July sun for a few days, the handles of the scythe being twisted in opposite directions, as evidence of the struggle. A scythe should be kept sharp and used for mowing grass, and not be left out, exposed to the sun or to rust.

15. Tamping Bars.—They should be made of seven-eighths iron, length $5\frac{1}{2}$ feet, sharp-pointed at upper end, have a tamping face four inches wide, and five-eighths inch thick, and weigh about 14 pounds, and the neck bent so that the tamping face will be in right position when bar is held at an angle of about 45 degrees. When tamping face gets too thin send them to shop to be refaced. Always be sure to remove enough dirt so that tie can be well tamped; reach under the rail so that all the space under the tie will be tamped. Never slight this work nor allow the men to do so. Have them understand that they must be particular about this work.

16. Track Flags.—It is very often necessary to make use of the flags, and it is very important that we should protect ourselves against any possible accident. We must not take it for granted that a train will not pass before a certain time, or that a certain place will carry a few more trains safely over. Always be on the safe side, remembering that in protecting ourselves we are protecting trainmen, passengers, property, and all concerned. A great many lives have been lost, and a vast amount of property destroyed, by improper flagging or no flagging at all. Always have the flags with you, and when placing them always place them at the extreme limit required by the book of rules which you are working under. Never place them short of the limit. Always send a trusty man to do the flagging. If flags are left without a flagman, be sure the stick is driven firmly into the ground on the engineer's side, and about three feet from the rail; flags when not in use should be encased in something that is water proof.

Where a flag is left without a flagman, torpedoes should always be left so as to be sure the flag will not be passed unnoticed. Always keep a supply on hand.

17. Tape Lines.—It very often happens that a tape line, after being wet two or three times, will shrink, and be too short; measure them once in a while and see if they are accurate. Of course it is best not to get them wet, but sometimes it cannot be avoided. Steel tapes would be the best, but they are not furnished. Have a box to keep the tape line in when not in your pocket. It is important that you always make accurate measurements; it will often save lots of trouble.

18. Track Level.—When surfacing track never try to get along without the level, but try the level every

day it is to be used, and see that it is correct. The old-fashioned level boards are not fit to surface curved track with. A good track level is one made of wood, $1\frac{1}{2}$ inches thick by 3 inches wide, bound with iron strap at one end, and the other end having an iron or brass cap fitted over it and an iron standard 5 or more inches long through it; standards to be used one-half inch square and graduated to one-eighth inch. Standard should slide easily either way, and have a set screw to hold it at any desired place. The end which has the standards in will, of course, be the heaviest, so the handle should not be in the center, but should be placed so the level will balance when picked up.

19. Track Wrenches.—Each section should have as many track wrenches as there are men in the gang. It takes a little practice to use a wrench quickly and handily; have the nuts tightened good, and then hit them a blow with the hammer and tighten them again. Where nutlocks are used nuts will not need to be as tight as where there are none. Wrenches should be made of one piece of steel, and have four sides to the jaws, so as to fit square or hexagonal nuts.

Monkey Wrenches.—One should go with every handcar, and don't use it for a hammer; keep it in good working order to tighten nuts with.

MINOR TOOLS.

20. Curving Hooks.—These need but very little care, but a lot of care needs to be taken when using them for curving rails. When curving rails above three or four degrees use a string and curve them to ordinates, so when using the curving hook in conjunction with lever and sledge exercise a little care or we will make ourselves lots of extra work.

Drawing Knives—Are very handy for putting in

new handles and are often handy when making repairs around tool houses or other buildings. They need to be kept very sharp and should have a special place in the tool house.

Grindstones.—This is a most necessary tool and when using it it should be turned steadily and tools held square to avoid wearing the face of stone uneven.

Hatchets.—One should always be kept on hand car, and when grinding other tools it should not be forgotten.

Straightening Iron or "Jim Crow," as we usually call it.—Almost every section has more or less kinky rails, and with this tool we can straighten the joints where they are crowded out too much. First, pull the spikes and plug the holes where the kinks occur, then use the straightener and the track will present a much better appearance. The "jim crow" is also very handy when we have rails to cut. Mark the rail all around with chisel and then put on the "jim crow" and break it. It saves lots of cutting.

Rakes are handy to clean up straw and rubbish around depots, warehouses and other buildings.

Ratchet Bits.—When drilling holes the bit should not be crowded too hard, as they are generally highly tempered and are liable to break at the point. See that the bit is in the ratchet straight and fits snug.

Ratchet Drills.—Keep them as free from grit and dirt as possible. When placing them for drilling a hole, be sure to set them straight, so there will be no crooked or misplaced hole.

Striking Hammer.—Every section should have one of these. Twelve pounds is about the right weight, and the handle should be a little shorter than for a spike hammer. Always use the striking hammer for

striking the chisel; a spike hammer should never be used for this.

Sight Boards and Spike Pullers.—Every foreman should have some kind of sight boards or blocks to use when taking out long sags. Another tool which is very handy is a short spike puller for pulling spikes where the claw bar cannot be used. In lieu of something better, a short pinch bar, such as engineers or car repairers use with their jacks, can be used to advantage. Bend them a little more at the heel and they will start spikes fairly well. However, the spike pullers offered by manufacturers are far better and handier.

Oil for Wooden Handles.—All wooden tool handles should be well oiled before being used; it prevents season checking to a great extent, and they wear smoother.

IMPORTANCE OF HAVING TOOLS READY FOR USE.

21. One of the most important things in railway service is time. Time represents so much capital invested by the company, and to make this investment pay dividends you must know how to use and care for the tools you use. Make an every-day practice of handling tools to best advantage, so that in case of emergency you may be prepared for anything that turns up. Think for a moment of the loss and inconvenience that is caused if one of the main lines of one of our great railway systems is blockaded for a few hours. In case of a wreck or washout, or any other accident that may happen to a railroad, and a big force is called out to repair it; then it is that you can make yourselves of valuable service by knowing how, when and where to use your tools, and have them distributed so that you do not have too many at one thing and too few at another; but have everything arranged so that the most work may be accomplished in the least possible time.

And if you do not make a practice of working systematically you will not be prepared to do so in an emergency. A proper handling of tools means a proper handling of men.

CHAPTER XX.—TIE PLATES.

PAST THE EXPERIMENTAL STAGE.

1. In the United States, Canada and Mexico tie plates are now being used as a standard on most of the largest and most important railroads, after practical trackmen had experimented with them for a number of years and found that there were great benefits resulting from their use. The main advantages of properly constructed tie plates are summarized as follows:

SAVE IN TIE RENEWALS.

2. It has been found that when the ordinary soft wood ties, such as white pine, cedar, red wood, chestnut, tamarack, and cypress are placed in track where traffic is heavy, the fiber of the wood will be crushed, abraded and destroyed by the wave motion of rail, long before they would have to be removed on account of natural decay, as described in Chapter IX.

The natural life of the soft woods, when used as ties, averages twelve years; but they have been known to be destroyed in six months under peculiarly severe conditions, and under ordinary conditions within a period of from two to four years. Hence the railroads of America have not used soft wood ties, except under the lightest traffic, until the tie plate came and proved its tie-preserving qualities. Since then it has been demonstrated through practical experience that by the use of a properly constructed tie plate the use of these soft ties may be extended to their full natural life of twelve

years, and that, when they are subjected to a wood preservative and placed in track with tie plates, they will last twenty years. From this it will be seen that tie renewals on roads using tie plates on soft ties will not be more than one-half or one-third of the requirements where no tie plates are used.

The density and compactness of the wood in oak and yellow pine ties is sufficient to withstand the destructive action of the rail on straight track for a period often equal to their natural life, which averages eight years. On curves, over three degrees, it has been found necessary to use tie plates to preserve the hard wood ties to the limit of their natural life.

AVOID ADZING IN MAINTENANCE.

3. The load upon the rail due to the wheels traveling over it is both vertical and lateral (Fig. 55), according to the surface of the track, making the strain greatest on its outer edge, and causing the outer rail flange to cut down into the fiber of the wood more quickly than on the inner (Fig. 56).

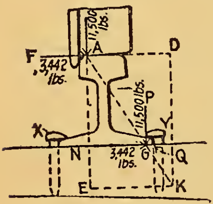


FIG. 55.

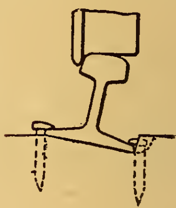


FIG. 56.

When the rail assumes this canted position the gauge is widened; this increases the lateral sway of trains which requires that track men draw the spikes, adze the tie beneath the rail to a level surface and then respike. This adzing requires the tie to be tamped and raised an amount equal to the depth of adzing, all of which could have been saved by the use of a tie plate.

MAINTAINS TRACK IN SURFACE.

4. Where no plates are used the old ties must be adzed several years before they are to be taken out of the track to maintain the rail level, and when so adzed they must be raised to restore the surface, hence the roadbed beneath them is destroyed and requires filling in and tamping under the adzed ties which leaves such portions of the roadbed soft and yielding, while other parts are thoroughly compact and rigid; the result is a bad riding track.

If all ties are protected with tie plates these conditions will not occur, the tie plate entirely preventing the cutting of the tie, and consequently the necessity for adzing and retamping, leaving the roadbed uniform, and making a smooth riding track. Thus a great saving in track labor is accomplished.

MAINTAIN GAGE.

5. By referring to Fig. 55 it will be seen that the lateral force tending to throw the rail to a wider gauge, is resisted by the outer spike only, marked "Y," which in its turn is supported by the fiber of the wood back of it; but that when a tie plate is used the widening of gauge can only then take place if both spikes Y and X together with the plate move laterally, which is impossible. Hence we have the full resistance of both spikes, plus that offered by the plate itself, to prevent widening of gauge, giving an increased safety in operation.

HOLDS RAIL VERTICAL.

6. Referring to Fig. 57, it is seen that of the two forces acting on the head of the rail, the vertical one is by far the greater of the two.

With the use of rail braces these two forces are transmitted to the tie as follows: The small lateral force

is transmitted directly to the rail brace and through it and the spikes holding it to the ties, but the much greater vertical force is transmitted to the tie directly at a point near the edge of the outer rail flange, and this force the rail brace is not designed to and does not resist, with the result that the tie is cut out and the rail brace is canted as in Fig. 58. By the use of the tie plate the much greater vertical force is resisted by the plate and is distributed over the tie. The much smaller lateral force is resisted by the inner and one or two of the outer spikes, according to the necessity of the case. This fact has become so well established that after a trial of tie plates most railroads in the United States having the sharpest curves and heaviest grades have abandoned the use of rail braces and adopted tie plates in their stead. This is notable in the case of the Norfolk & Western, Baltimore & Ohio, Denver & Rio Grande, and other roads.

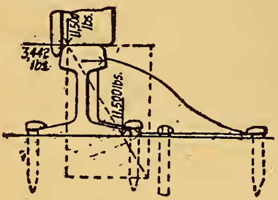


FIG. 57.

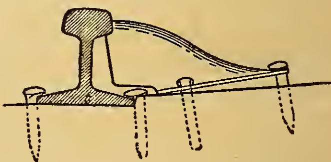


FIG. 58.

The use of the tie plate on curves insures a normal position of the rail, prevents the rail from rolling, which, in turn, insures a true gauge.

A properly constructed tie plate increases the life of the tie and thus decreases the cost of tie renewals; it maintains good track and thus makes a large saving in the labor of track maintenance.

NECESSARY FEATURES OF A GOOD TIE PLATE.

7. A good tie plate must become part of the tie into which it is bedded, in order to avoid any movement between plate and tie. This is accomplished by longitudinal flanges on the plate entering the tie parallel with its fibers, and compressing them without injuring them; the reactionary pressure of the fibers upon the flanges of the plate makes the latter practically a part of the tie.

A well-known illustration of this fact is that when an ax is driven in a piece of timber parallel with the grain of the wood, it remains firmly wedged in, while if cut across the grain it has no grip at all, and is easily worked loose.

A good tie plate must have sufficient strength to distribute the load from the rail to the outer ends of the plate without bending, for if this is not the case the plate buckles, as shown in Fig. 59, loosens from the tie and destroys the fibre of the tie rapidly. A point to be guarded against is the using of too much metal in the plate; if this occurs it will work itself loose from the tie by its own inertia and destroy the wood fibres. The flanges act as girders and distribute the load on the rail to the extreme end of the plate in a much more economical manner than if the plate is increased in thickness.

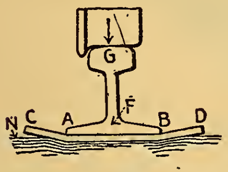


FIG. 59.

There must also be provision made for sand to escape from the top of tie plate; otherwise the grit getting between rail and plate, will gradually destroy both rail and plate; but with the proper means of escape, such as channels or ducts, it has been found by experience that it has but little effect upon the plate.

THE PLATE THAT FILLS ALL THE REQUIREMENTS.

8. The Q. & W. Tie Plate is the latest development of the tie plate in the United States, and is a combination of the Servis and Wolhaupter patents uniting the most valuable features of both into one. The flanges of the Q. & W. enter the tie parallel with the grain at right angles with the rail. The upper portion of the corrugation between the flanges is of arch construction on top. The corrugations are flattened somewhat to give a surface support for the rail base.

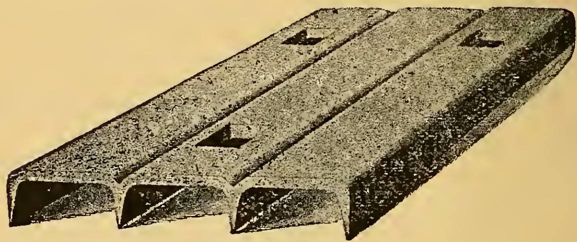


FIG. 60.

This plate fulfills all the requirements of a good tie plate, as having the flanges parallel with the grain of the wood they readily separate the fibers and imbed themselves in the wood, thus becoming a part of the tie.

The plate being corrugated, it has the same relative strength to a flat top plate as a corrugated piece of sheet metal has to an ordinary plain piece. In addition to these corrugations it has the flanges below, which act as girders to distribute the load on the rail to its outer ends. The channels or grooves on top allow the escape of sand, as mentioned in paragraph 7, and this feature is very important.

Being corrugated it may be very much lighter and have an equal strength with a plain plate, and thus have a small amount of inertia to work loose. Another fac-

tor commending the Q. & W. plate is that it has 40 per cent. of its total weight on the top wearing surface. When the top of this plate is worn half through only 20 per cent. of the metal is removed, and its strength remains substantially as before.

CHAPTER XXI.—WRECKING.

1. The first duty of a track foreman when he receives a notice that there has been an accident, and he is wanted there, is to collect his men and take his hand car, and all his portable tools, even those which he thinks he is not likely to use. He should not go short of tools expecting that the other foreman there will have enough. The other foreman may think the same, and valuable time will be lost by the want of forethought of both.

ON THE GROUND.

2. When a track foreman arrives at the scene of accident, he should proceed immediately to do whatever work, in his judgment, would contribute most to putting the track in a passable condition for other trains, notwithstanding the absence of his superior officer, who may not be able to reach the wreck for several hours. If the track is torn up, and the cars do not interfere, put in ties enough to carry a train safely over where you can. If the rails are bent out of shape secure some from near by, if it is possible. If this cannot be done, get as many as possible of the damaged rails to their proper shape, and spike down in the track.

If a small bridge or culvert has given away, crib it with ties until you can cross it with track.

If you cannot procure ties along your section, and

many are not needed, remove a part of the ties from the track where it is full tied, and where it will leave a sufficient number in the track to make it safe for the passage of trains.

In the same manner, if you are short of bolts and spikes and too much time would be lost by going after them, borrow some from track where they can be spared and fix track to let trains pass.

TO SQUARE A CAR TRUCK.

3. If one or both trucks beneath a car should leave the track at once and turn across it, as is often the case, uncouple from the car and hitch a switch rope to the corner of the truck and to the draw head of the car next to the one which is off the track. Then pull the truck into a position parallel to the track, after which it can be put on the rails with the wrecking frogs.

If the car should be loaded very heavily, it might be advisable to raise the end with jacks before squaring the truck. If the right man undertakes this job, the train need not be delayed over thirty minutes.

WHEN A CENTER PIN CANNOT BE USED.

4. Sometimes when a car leaves the track, the center pin breaks, or is so badly bent that it cannot be used again. This often happens on the road when there is nothing at hand to remove the crooked pin. In such a case, if the car is empty, or not heavily loaded, it is best to roll the truck from beneath the car off the track, and haul the car into the station carefully supported on that end by the regular coupling pin and link.

When the ends of a broken center pin do not project, the end of a car can be jacked up, the truck placed in position, and the end of the car again allowed to rest in its place on the truck, after which, if watched carefully, the car can be hauled a long distance.

WITHOUT AN ENGINE.

5. It often happens that car gets off the track in such a place that it is impossible to get the help of an engine to pull it on again without considerable delay. When a case of this kind occurs, and there are other cars on the track near by, take the car nearest to the one off the track, and couple the two together with a chain, or a rope long enough to give plenty of slack. Then get together what men are available, and push the car which is on the track close to the wrecked car. When you are ready to pull the wrecked car upon the track, start the car which is coupled to it away from it as fast as the men can push it. The jerk, when the slack of the line is taken up, will pull the car on the track as well as an engine can do it. If you have men enough, use for the motive power two or more cars, if necessary. This is what is called "slacking a car onto track."

CARS OFF ON TIES.

6. When cars have got off the track, and are still on the ties, it is best to put blocks or ties between those in the track to keep the wheels from sinking between the ties. By doing this at once, before attempting to put the cars back on the track, will generally save considerable time and labor.

OIL THE RAIL.

7. If an engine or car mounts the outside rail of a sharp curve, and persists in running off the track, oil the rails thoroughly where the most trouble is experienced. This will generally allow the engine or car to go around the curve without leaving the track.

Very rusty rails on a curve track, which has not been used for some time, often cause the wheels to

mount the outside rail of a curve, the surface not being smooth enough to allow the wheels to slide.

BROKEN SWITCHES.

8. If at any time you find the connecting rod of a stub switch broken, or you want to use the switch and have no switch stand, slip a car link between the ends of the lead rails, allowing enough of it to project to hold the ends of the moving rails in place, or take a piece of plank of the right shape, and use it in the same way as the link. This is better.

CAR TRUCKS IN THE DITCH.

9. When the car trucks are thrown some distance from the track in a wreck, the quickest method of putting them on the track again, if you have no derrick car, is to take bars and turn them almost parallel to the track, but with one end a little nearer to the track. Hitch a rope to this end of the truck, and to the engine, or the nearest car which is coupled to the engine, and the truck will pull onto the track easily, if there is nothing to obstruct its passage.

TO CONNECT BROKEN CHAINS.

10. A link made of iron or steel, and fashioned after the pattern shown in Fig. 61, is very handy to have when at a wreck, pulling cars or engines with a chain. If a chain breaks the two broken ends can be brought together, and fixed in this link as if held with a grab hook.

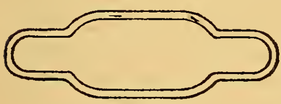


FIG. 61.

TO TURN A CAR TRUCK ON SOFT GROUND.

11. When car trucks are sunk in soft ground at a wreck, and there is no derrick car or other lifting apparatus at hand, a good way to handle them is to place

a tie cross way in the ground, about four or five feet from the truck, then place two more long ties or timbers, with their centers resting across the first tie, and their ends in front of the truck wheels. The truck can then be pushed up on top of the long ties as if on a track. When it is centered over the bottom tie, the truck can be easily turned to run in any direction.

TO PUT A WRECKED GRAVEL PLOW BACK ON CARS

12. Trackmen in charge of a ballasting outfit if they are new at the business, are often at a loss to know the quickest way to put a plow back on the cars, if it should accidentally be pulled off on the ground. The best way to do in such a case is to roll the plow or pull it with the engine and cable into the same position on the track that it would occupy on the cars; then raise up the snout of the plow until you can back the end of a car under it, hook the end of the cable to the plow, block the car wheels and pull the plow on to the car with the engine.

SLIDING A CAR ON A TIE.

13. If the hind truck of any kind of a car should by accident be derailed, broken, or rendered useless, the car could be taken to the next station by uncoupling it from the cars behind it. Remove the disabled truck from the track; then take the caboose jacks and raise the body of the car enough to slip a tie under it across the track rails; let the car down upon the tie, and by running carefully the car can be hauled to the station or side track, sliding on the tie.

If sliding the disabled car on a tie is not practical, it is often a good way to block up both ends of the car on ties and move the forward truck under the other end of car and haul it to station with one end resting on the coupling; or put another truck under the for-

ward end, that being the most convenient way in some cases.

LOADED WRECKED CARS.

14. It is always best, when a wrecked car is loaded, to remove the load, or transfer it to another car on the good track. Outfits starting to go to a wreck should provide themselves with all tools and appliances necessary for this purpose.

BROKEN CENTER PINS.

15. Car-truck center pins, which have been twisted or broken in a wreck, may be removed by going inside the car, and cutting away with a hammer and cold chisel the iron ring which forms the head and shoulder of the pin. The pin may then be driven down through the bottom of the car.

There should always be a man on hand at a wreck to look after such jobs, and promptly remove all broken brake-beams, hanging irons, etc., so as not to delay the work after the cars are picked up, or ready to be put upon the track.

PULLING ON A CHAIN OR ROPE.

16. When pulling on a chain or rope with a locomotive at a wreck, care should be taken not to have too much slack, as chains break easily. The same is true of switch ropes, but when they are new or not much worn, they will stand a greater slack strain than a chain will. Wire cables are preferable to either a chain or a rope, for pulling, and they will stand a much greater slack strain, if not allowed to become twisted out of shape.

There is always danger of chains or switch ropes breaking when engines are pulling on them at a wreck, and those working near should not be allowed to stand too close to them.

A DEAD MAN.

17. What is generally termed "a dead man" is a device sometimes used to anchor a guy or stay rope, where wrecking cars, engines or derricks have to do very heavy hoisting or pulling. It is made by digging a trench five or six feet deep, at a proper distance from the track and parallel to it. A narrow cross trench is then dug, slanting upward from the bottom and middle of the first trench, to the surface of the ground. A good track tie or heavy timber is then buried in the first trench, and the rope is passed down through the cross trench and secured to the timber.

WRECKED ENGINES.

18. The first thing to do with a wrecked engine, if the frame is good, is to take jacks and put the engine in an upright position, such as it would occupy if standing on the main track. It may then be blocked up and raised sufficiently to place under it rails and ties, forming a temporary track. The main track should then be cut at a rail joint, and lined out in an easy curve until the ends of the rails are in line with the temporary track. The tracks should then be connected and the engine pulled upon the main track. If the engine stands at such an angle as to require a very sharp curve in the track over which it is pulled, put plenty of oil on the track rails, and elevate the outside rail of the curve.

If the engine is only off the rails, and still on the track ties, additional rails may be spiked down to the ties in front of the wheels like a switch lead, and connected with a pair of the track rails. The engine may be pulled on again over this lead and the main track closed. This method is quicker and better, for putting

a derailed engine on the track when more than one truck is off the rails, than using frogs or blocking.

HOW TO WORK AT A WRECK.

19. The first thing to do at any wreck of importance, where cars block the main track, is to use the first locomotive which can be put into service, and with switch ropes pull clear of the tracks all cars, trucks, or other wreckage which cannot be readily put back on the track with the facilities at hand for doing such work. Proper care should be taken, in doing this part of the work, not to injure freight in the cars. When necessary, remove it from the wrecked cars to a place of safety, and pull the cars and trucks into a position alongside the track, where it will be handy for the wrecking car to pick them up after it arrives.

The moment the track is clear of wreckage, the track force should go to work and repair it, and quickly put it in good condition for trains.

Track foremen should not allow their men to become confused or mixed up with other gangs of men which are present at a wreck, except when it is necessary for more than one gang of men to work together; even then the foreman should keep his own men as much together as possible, so as to always be able to control their actions and work them to the best advantage.

No matter what part of the work at a wreck a foreman is called upon to do, he should act promptly, and work with a will to get the wreck cleared up, and the track ready for the passage of trains with as little delay as possible.

CHAPTER XXII.—GENERAL INSTRUCTIONS.

BOARDING ACCOMMODATIONS.

1. Track foremen should always see about securing boarding accommodations for the men working under them. Do not make a favorite of any particular house in town, but select the hotel which will give the best accommodations and the cheapest.

The wages of track laborers as a general rule are low, and very few of these men can pay their board in advance. For this reason the foremen should see that board bills presented by hotel keepers against any of their men are properly signed, corrected and sent into headquarters promptly at the end of every working month, and when a man is discharged, if he is in debt for board, the amount of his bill should be sent in with his check to the superintendent to be deducted therefrom. By paying particular attention to the foregoing instructions, track foremen will always be able to more readily secure men when wanted. The hotel men will not refuse to keep them, and you will save yourself and the officers of the company a great deal of annoyance and useless correspondence. Never keep at work a dead beat or an habitual drunkard, and you will materially assist in bettering the condition and reputation of men employed in the track service.

DISCHARGES.

2. Upon the day on which a man is discharged the

foreman should make out his time in full on the time book, and write opposite his name on the time book, "discharged," or the letters C. G., which means certificate of time given.

The foreman should always fill out a discharge check, using the regular blank form for that purpose. The man's name should be written in full on the discharge check and spelled in the same way as on the time book. His occupation, number of days worked, and amount due him should also correspond with the same on the time book. The discharge check should be signed by the foreman and forwarded to the roadmaster for approval. A board bill should also accompany the discharge check whenever there is any deduction to be made from a man's wages for that purpose.

Foremen should not discharge any of their men without sufficient cause, except when they have received an order to reduce their force; nor should a foreman keep any more men than the regular force allowed him without orders from the roadmaster.

RIDE OVER YOUR SECTION ON THE ENGINE.

3. Section foremen should take an occasional ride over their section either on the engine or on the back platform of the rear coach or caboose of a train; and while riding over the track they should not make a pleasure trip of it, merely, but should watch closely how the cars ride, and note all the worst places in their sections, and note what causes these places to affect the smooth running of the train. A train running at the speed of 45 miles per hour does not ride as smoothly as a train which only travels 20 miles per hour on the same track, because the cars which travel the slowest have more time to get righted after the

wheels meet with a place out of line, level, gauge or surface, while the fast trains may meet with, and pass several of these slight obstructions within a second of time, thus having no time to regain its balance. When a train runs along smoothly for a distance and suddenly swings to one side, if it be on a straight track, that place is either low on that side, or is badly out of line or gauge. If the train be on a curve, and the car swings heavily toward the higher rail, there is not enough elevation in the curve at that point. If the car swings toward the inside rail of the curve, there is too much elevation at the outer rail at that place. A low joint on the inside rail will cause the train to swing to that side, and the striking of the wheel flange against joints that are hooked in out of line on the outer rail will also throw the car toward the inner rail. A foreman can soon become expert in distinguishing the slight difference in the motion of the car as it swings to either side of the track, and tell the cause by examining the bad places in the track soon after riding over it on the train.

FOLLOWING TRAINS.

4. Track foremen should not, at any time, secure their hand or push cars behind a moving train to save the labor of pumping or pushing them. Many serious accidents have happened from this cause. If a train should slacken speed, or suddenly stop, with a hand car attached, it would be hard to prevent the car from going under the coach or caboose, and the men on the car might be injured or killed.

ACCIDENTS.

5. All personal injuries to men working in track service should be reported on the proper blank form by the foreman to the roadmaster, and all accidents

resulting in damage to the railroad company's property should also be promptly reported to the roadmaster. When there are no suitable blank forms a written report should be made, and it should be signed by witnesses.

GO OVER THE TRACK.

6. Section foremen should always, in very stormy weather, go over their sections and examine all culverts, bridges and other places liable to wash, and report condition of track to roadmaster. In going over their section, track foremen should be very thorough in their examination of everything in their charge. See that the telegraph lines are in good order; if they are not, repair them when you can, and report to train dispatcher or roadmaster any defects that may need the service of the telegraph line repairer.

Foremen should also notice the condition of all snow or right of way fences, especially the latter, and repair all breaks in them as soon as found. Gates left open by farmers should be closed and secured. Unreliable men, or those ignorant of their duties, should never be detailed to patrol the track.

RAISE UP THE WIRES.

7. When telegraph wires are found down after a storm, section foremen should hang them high enough on the poles to insure their working properly, and prevent cattle or teams crossing the track from running against them.

EXTREMES OF TEMPERATURE.

8. Whenever the temperature changes suddenly there is always danger whether the changes be to extreme heat or extreme cold. Section foremen should be very particular to go over and examine all the track

on their sections to discover places where track has been kinked and thrown out of line by the heat, or splices broken and rails pulled apart by the extreme cold. Foremen should remember that accidents of the kind mentioned are liable to happen at any point on the road, even where the rails seem to have the proper allowance for expansion, because the change of temperature may come on quickly. Places where the ballast is light, or where the track is not filled in between the ties, are the most liable to be affected.

TRACK JACKS.

9. Every section foreman should have a track jack along with his other track tools, and he should always carry it with him on the hand car, and have it ready to use whenever it is necessary to raise track.

There are few things that look more ridiculous than three or four men making futile efforts to raise a rail of track, with a long bar or track lever, and a block of wood which is either too high or too low. The ingenuity or ignorance of the whole gang is displayed a score of times during the day, whenever the block will not do to raise the track to the proper height, and valuable time is lost in trying to find a stone, a chunk of wood or a spike to increase the leverage, and which is seldom or never thought of until the moment it is wanted. Sometimes the spikes are pulled out of one or two ties in every rail length, and the track is raised from the top of the ties. This way also causes a considerable loss of time, pulling the spikes and respiking the ties, besides the injury done the ties, when the old spike holes are left open to rot the wood. Raising track with a lever, pulls the rails out of line much more than raising it with a jack, and makes it more difficult to get back to place, often loosening the spikes where

the ballast is heavy, and the track is laid with soft ties.

A good track jack is one of the best and most economical tools that can be used on a railroad.

In order to avoid accidents when track is being raised, the track jack should be set on the outside of the rails. In this position the pilot of an engine, if it should strike the jack, will knock it clear from the rails. But there is no necessity of using a track jack immediately ahead of the passage of trains, or when they are due at that point, and the men can be employed at other work for the time. A track jack placed inside the rails which could not be removed in time, caused the derailment of a passenger train on the Old Colony Railroad and ten persons were killed. Always properly protect yourself with flags when using a jack.

THE SPIRIT LEVEL.

10. Foremen should never go out on their sections to surface it without taking the spirit level with them. It should be used continually, especially on track which was never ballasted, or which was surfaced hurriedly without using a level. Never listen to ignorant or conceited track foremen, who will tell you that they can put up as good track without using the track level. It is impossible. If you have surfaced a piece of track to a perfect level, then you can sight the depressions in the surface without using the spirit level, when going over it a second time, if the track has not become rough.

It is the rule more than the exception, that where a track is newly laid and ballasted with dirt, the surfacing is poorly done, and the spirit level seldom or never used.

Section foremen in charge of new track laid on dirt should make it their business to improve the line and

surface as fast as possible with the force allowed them, before the track settles, or the dirt becomes a solid mass. While the ties and rails are new is the time to make a good track.

SURFACE BENT RAILS.

11. In wet cuts, or other low places, the track often becomes very rough, and the ties sink into the mud in places. The rails then, if of light weight, become more or less surface bent before the track can be raised up, or repaired properly. If the surface bent rails cannot be replaced by good rails before the track is ballasted up they are apt to cause the section foreman much trouble in trying to make them remain in true surface, if he does not understand how to straighten them. This can best be done by the following method: If, for instance, a rail bows up at the quarter or the center, make the ties solid at each end of the bent place some warm day, then remove enough material from under the ties, where the rail is bent, so that the weight of an engine passing over the rail will bend the bowed place, just as much below level, as it is then above. After a train goes over you will generally find the rail has resumed its proper shape all right. If the bend in the rail is downward, hang the center of the bent place upon one or more solid ties, according to the length of the bend, and allow the balance of the track under the rail to remain as it was. Joints which have been allowed to remain low for some time, often cause the rail to become surface bent in the short quarter, and they are very difficult to keep up ever after, unless the kink is taken out of the rail.

A loose joint tie, in gravel or sand ballast, will soon pump out enough gravel to cause the rail to bend a short distance from the end, unless it is noticed by

the track foreman, and taken care of at once. When the track foreman wishes to straighten any surface bent rails, he should always signal the first train, and have it run slowly, because there is danger of the rails breaking where they are not fully supported. Surface bent rails, which are so bad that they cannot be straightened while in the track, may be taken out and fixed with the curving hook and lever.

LOW JOINTS.

12. When picking up low joints in gravel or stone ballasted track, particularly where the depressions are only slight, if sufficient force is allowed, track foremen should always use tamping bars, or tamping picks, according to the nature of the ballast, to tamp up the track ties to the proper surface level.

There are many things other than a weak foundation which make low joints in track. Loose bolts in the joint fastenings make low joints, because they allow the joints to bend down under the weight of the engine and cars. Bad gauge and line make low joints, because the cars, when trains run fast, are thrown heavily from one side of the track to the opposite, and the joint being the weakest point is liable to be affected the most. A wide space between the ends of the track rail also make low joints, and assists the car wheels to batter the ends of the rails.

When rails are laid on soft wood ties, or when the ties have commenced to decay, you will generally find that a low joint is wide in the gauge between the rails. Make low joints a scarce article on your section of track, and you will quickly have a good track, and a good reputation as a track foreman.

The conviction gains ground daily that low joints

are due in a great measure to the faulty construction of the ordinary angle bar joints, and this theory is borne out by the fact that roads using improved Joint Fastenings have very little trouble in this respect. There are numerous devices on the market now which have some merit as an improvement, but the general opinion among trackmen is that the Continuous Rail Joint and the Weber Joint* are the most efficient.

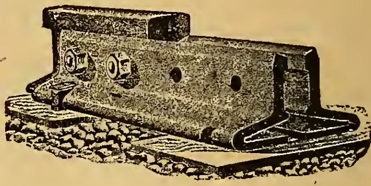


FIG. 62.

We show in Fig. 62 the Continuous Joint. As will be seen the two angle plates give a continuous support to the flanges of both rails, thus making it impossible for either rail end to dip, while perfect alignment is secured by the vertical flanges of the angles.

The Weber Rail Joint is in use on a great many of the American roads. The principles involved are that the base plate prevents the ends of the rails from dipping, the upright leg insures great strength of the joint, and the wood fillers absorb the vibrations of the rail, and also act as a nut lock for the bolts.

The use of either of these two named Joint Fastenings will save a large amount of labor annually in the operation by keeping rail joints to a true surface.

EXAMINING TRACK.

13. When the track rails on a section become badly worn, and need to be repaired often, or when the ground is frozen solid in winter, section foremen should go over their sections daily, and examine the

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*See page 314 for description and illustration of the Weber Insulated Joint.

track thoroughly for broken or cracked rails, removing from track such rails, and replacing with good ones.

It is the duty of foremen never to deviate from this rule unless a regular track walker is employed for this purpose, or when they have orders from the roadmaster to the contrary.

The section foreman is responsible for the condition of the track in his charge, and he should do everything in his power to contribute to the safety of passengers and trains passing over it. Report all broken rails to the roadmaster as soon as found, giving brand, weight, age, etc.

SCARCITY OF REPAIR RAILS.

14. When repair rails are scarce, and a foreman cannot procure enough to exchange for damaged rails in his main track, he can with only a couple of extra rails keep his track perfectly safe by commencing in time to bring into station the worst rails on the main track.

Take the extra rails out on the section, if good and of the proper length, exchange them for two battered rails, bring the two battered rails into the station and put them in the yard, or in track some place near the station, and get two more good rails. These you take out on section as before, and exchange for battered rails. In this way a foreman may exchange four or five carloads of rails, or about one mile of steel, until he receives a supply of repair rails.

Battered rails are safer within one-half mile of a station at the track foreman's headquarters, than out on his section, because trains run slower there. Battered rails are less liable to break near the station. They are also much easier watched, and taken care of.

When repair rails are received the battered rails can all be removed at once.

CHANGING BATTERED RAILS.

15. The best method for changing rails which have become unfit for use in the main track, when the rails furnished for repair are of a different length from those in the main track, is as follows:

Put in track near the station a string of repair rails, and take out rails of a proper length to change the battered ones out on the section. In order to do this right, and save unnecessary expense and labor, always try to have the number of repair rails you put in track replace a greater or less number of rails of a different length without any cutting. If you have not the right number of rails without cutting one use a number of rails that will give the least waste.

EXAMPLE.

15 26-foot rails equal 390 feet.
13 30-foot rails equal 390 feet.

OR

7 30-foot rails equal 210 feet.
8 26-foot rails equal 208 feet.

As will be seen in the above example, there are only two feet to be cut from the last 30-foot rail of the 7 to replace 8 26-foot rails, and for this waste a foreman should select (if he has it) a rail battered on the end, that will give the required 28 feet of good rail.

EXTRA WORK.

16. It is customary on most railroads to call upon the trackmen to do extra work occasionally, such as assisting the telegraph line repairer, the bridge carpenters, pump repairers, etc., whenever these gangs cannot well perform the work alone, or when a suffi-

cient force of men canot be procured to do the necessary work.

Track foremen should not assist with their men at any kind of extra work without orders from the roadmaster. When such orders are received the track foreman should only give the amount of help required, using all of his men or only part, as is necessary. Never employ all of your force when a less number of men could do the work as well, unless your orders require it. Charge accurately on the work journal, and to the department to which it belongs, all extra work performed by your men during the month. Whenever you do any extra work, for which there is no printed heading on the work journal, put down the time in some column which you are likely not to have any occasion to use for the work specified in it, and state, in writing in the same column where you put the time, what the labor was.

TRAIN ACCIDENTS.

17. In case of an accident to a train, the section foreman who is called should take his men and tools and go to the place, no matter whether it is on his section or not, and give all the assistance possible. Foremen should obey the conductor of the train, and work under his instructions until the arrival of the roadmaster, or until they receive other orders. Section foremen should not wait for orders from their roadmaster to do any extra work which they know to be absolutely necessary, but should do the work at once, and remain out with their men until everything is safe. If a foreman is notified by trainmen or others of something wrong on a section adjoining his own, such as a broken rail, a fire along the right of way, or the telegraph wires broken or down, he should make all

possible speed to get to the place of danger without questioning his right to go, because it may not be possible to notify the proper foreman, and any delay may cause the company considerable loss.

AT WRECKS.

18. Whenever there is a wreck on the road, the foreman on whose section the accident happens, should keep an accurate account of the labor and material expended in repairing the damage done to the track. This account, together with the one of the damage done to rails, ties, spikes, bolts, or to the grade, should be put in the form of a report, and properly sent to the roadmaster immediately after the track is repaired. Time of men working at a wreck should be charged to that account on the work journal.

WATER STATIONS.

19. At all the water stations the section foreman should note the amount of water in tanks when passing, and where wind engines do the pumping, they should be oiled often, and any defects in them or the pumps should be repaired, if possible, or reported by telegraph to the roadmaster. Section foremen and their men should pump water into the tanks whenever the wind engine fails to supply enough for trains. When it is necessary to pump by hand, foremen should commence to pump before there is any danger of the supply in the tank being exhausted. Where steam pumps are to furnish the water for trains, section foremen should assist the man in charge to do any necessary repairing which he cannot do alone. Section foremen should always be ready and willing to get out their men day or night, to do work where their services would be valuable to the company.

TRESPASSERS.

20. Foremen should see that no person is allowed to erect dwellings, stables or other buildings within the limits of the railroad company's right of way, or in any other manner trespass on the company's property, without permission from the roadmaster or superintendent.

PROTECT FENCES.

21. When burning grass, weeds or other material along the right of way, foremen should be very careful and protect the fence from fire. Never go away from a place where you have been burning rubbish, and leave any fire behind you, no matter how small the fire, or how harmless it may appear. It is always dangerous until extinguished. If part of a fence should accidentally be burned, or destroyed from any cause, the damage should be reported at once to the roadmaster, giving a correct list of the property destroyed, and location of same, so that material to repair the damage can be sent there promptly.

RAILS OF DIFFERENT HEIGHTS.

22. All rails of different heights, where they meet at a joint, should be connected with a step splice, and an iron shim should be put under the base of the low rail to give an equal bearing with the high rail. The iron shim should have slots punched in the sides so that spikes can be driven in to keep it secured in place. Instead of the splice it is better to use a proper form of improved step joint.

EXPANSION BLOCKS.

23 When it is necessary to use short pieces of rail, called expansion blocks, to close up an open joint between the ends of two rails, the holes in one end of

the splices should be lengthened so that the joint can be full bolted and properly secured. The expansion block in a joint should always rest on the center of a sound tie.

SWITCH STANDS.

24. All switch stand targets should show white, when locked on the main track, also on all tracks running parallel to the main track, when connected at both ends. The switch target should show the red signal for an open switch when thrown for a spur track, and the switch should be thrown back to position on the through track, and kept locked, except when the spur track is in use.

ABSENT FROM DUTY.

25. Track foremen should never be absent from duty, unless by permission from their roadmaster, except in case of sickness or from some other unavoidable cause, and in such cases the roadmaster should be notified immediately.

EMERGENCY RAILS.

26. When it is possible to avoid it, it is recommended that track foremen leave neither track material nor tools out along their sections over night. But on roads where snow troubles in the winter time, and section foremen have long sections, it is a good policy to have repair rails, with splices bolted to them, placed at convenient distances, one or two miles apart, along the section, where they can be easily reached. These rails can be used in case of emergency to replace a broken rail in the track, and the splices will also be handy to replace broken ones, without the necessity of going perhaps several miles through snowdrifts, back to the station, for the material wanted. To prevent the rails

or splices from being covered with snow, they should be secured on posts set with their top two or three feet above the surface of the ground.

The condition of the rails as to wear should decide the number of emergency rails to be distributed along the track. Of course, where the rails in the track are badly worn, and broken rails are common, the number of emergency rails should be more numerous than where the track is newly laid, and the rails not much worn.

EXTRA MEN.

27. When you are about to have an extra force of men, larger than you have been used to working, take a little time to plan how you will distribute the men to accomplish the most good. Organization is one-half the work.

A PROMPT REPLY.

28. Whenever you receive a message from your roadmaster which requires an answer, don't wait or delay, but answer it promptly and correctly.

GET ACQUAINTED WITH YOUR SECTION

29. Every section foreman, as soon as he has been appointed to take charge of a section, should make himself thoroughly acquainted with every part of the piece of road in his charge. Get the numbers of all the bridges and culverts on your section, and the distance from the station north, south, east or west. Get the brand of iron or steel, and if it is of different makes get the amount of each, and find when it was laid, also the length and kind of rails in your side tracks, number of panels of snow fence on your section, height of bridges from the ground, number of public crossings, signs, etc. Keep this account where it will be handy to refer to at any time, and keep it corrected from time

to time. By doing this you will be able to answer any questions asked by officials of the road about any part of your section, and in case of a wreck or washout you will be able to locate that place at a moment's notice, and give a close estimate of the kind and amount of material necessary for repairs, in case of damage to track.

THE PROPER WAY.

30. Find out from your roadmaster the correct way of keeping your time, and filling out any other monthly reports that you have to send in to his office, and make them out as directed by him. You may have a printed form of some kind to fill out. Answer what is asked in the headings on form, but never omit or add anything.

WORKING NEW MEN.

31. If it is necessary to work new men on your section, who have never worked on track before, do not lose your patience if they are a little awkward in doing the work. If you can do so, pair these men with older hands. Take a little trouble to show them how you want the work done, in a manner that will give them confidence, and in most cases you will accomplish more good than by using the blow-and-bluster method so common with some foremen. Remember you needed instructions once yourself.

CLEAR WATER PASSAGES.

32. No vegetable matter, grass, etc., should ever be allowed to accumulate under bridges, or near the mouth of culverts, or any other material that would be liable to catch fire easily, or stop the passage of water.

NEAT STATION.

33. Section foremen should keep the station grounds clean and neat, and all track material should

be piled up in several lots. There should be no disorder; there should be a place for everything, and everything in its place. All stray links and coupling pins that are fit to use should be picked up, and left where they will be handy for trainmen when wanted. All of the station grounds not occupied by tracks, or covered with ballast, should be allowed to grow up in tame grasses. Such plots should be kept nicely trimmed around the sides and ends, with a view to having them of a regular form, and they should be lined parallel with adjoining tracks. No rubbish of any kind should ever be allowed to accumulate upon tracks, or on the ground close to buildings. It should be taken away and dumped into places which need filling. Section foremen should not spend too much time working around the station, but do what is required there when other track work is not pressing, or when the weather or extra jobs interfere, and take up so much of the day that it would not pay to go out on the section.

EXPANSION AT SWITCHES.

34. Where stub switches are used it is often necessary to change the rails in the spring and fall to adjust the expansion at the head block to the change in temperature. If the rails' ends on each side of the switch could move freely in the angle bars and were laid in the first place with proper expansion, it would not be necessary to change rails. But on account of tight bolts and angle bars becoming rusted to the rail the line of rails are forced by the expansion toward the head block, where no resistance to expansion is offered. Now if there are openings at the joints of rails near the switch, the bolts ought to be loosened until the expansion is absorbed. Then if the dirt is cleaned out of the joints and oily waste (which may be found around all

sidings) is packed between angle bar and rail, the rails will contract and expand at each joint without forcing the rails toward the head block. But if no opening exists between rail ends and it is necessary to provide expansion a rail will have to be cut to do so. A 30-foot rail does not make a good slide rail because the web often splits through the bolt holes, and although half angle bars are often bolted on to prevent this, they do not prove effective, as the splitting does not seem to be caused by compression, but by the jarring and vibration set up by wheels running over low head blocks. If this opinion is well founded, the half angle bars are useless, and by the wedge-like pressure they exert between the base and head of a rail they may assist instead of preventing the tendency to split. At any rate, if the end of rail resting on head chair has no bolt holes it will not spilt as readily as if it had. Therefore, a cut rail about 29 feet long will make a better slide rail than one 30 feet long, and where it is necessary to change it a battered 30-foot rail can be cut and substituted without loss of material. When changing battered slide rails the opposing switch rails if battered should be changed, also.

A material point in preventing excessive expansion and contraction around switch consists in keeping good ties under joints and shoulders and spikes in every slot in the angle bars. No plan intended to prevent the creeping of rails will be successful if this point is slighted in any way.

LOOK OVER THE YARD.

35. Yard foremen should have a reliable man as trackwalker, who should examine all important switches daily. If his time will permit he should also look after and attend to keys in switch rods to frog and

guard rail bolts, and if the yards be small he may also remove cinders from the tracks and attend to switch lamps. But it would be a mistake to put too much work on the trackwalker, as it would have a tendency to make him hurry over the yards and not give it a careful inspection. All large yards should have a trackwalker, a lamp man and one or two yard cleaners, and these men should never be taken from their work.

LIPS ON STUB SWITCHES.

36. On a road where stub switches are used, a foreman should see that no lips form where the moving and lead rails meet; and that the track lines are true, no matter which way the switch is turned. To guard against having lips on the rails of stub switches where they meet in the head chair, the head rods on the ends of moving rails should fit as tight as they can be driven on. No lost motion should ever be allowed to get in any switch connection. Switch stands should be bolted to the head blocks with the nuts on top.

BENT SWITCH RAILS.

37. Brakemen, when in a hurry, often pull the switch lever over before the trucks of the last car of a train are off the moving rails of a switch. This makes a kink or bends the rails out of line, besides, it often forms a lip at the joint in the head chair. The quickest way to fix a pair of moving rails, that have become bent as above stated, is to take out one of the rails and turn it end for end. This makes the bow pull in opposite directions, and in most cases will keep a switch all right until it can be repaired, or new rails put in. When the bend in moving rails is toward the side of track from which switch turns off, drive a stake at the ends of a couple of ties oppo-

site the bent place in the rails, and drive spikes in these ties outside the bend part of rails to keep them in line. This will do temporarily when you have not the time to straighten the rails.

THE MOVING RAILS OF STUB SWITCHES.

38. The moving rails of stub switches should never be cut except when battered. The best method of keeping the moving rails in good condition is to have them of the correct length, and to keep the joints in the head chairs just open enough so that the switch can be thrown easily in warm weather. When the rails begin to contract in cold weather, a pair of extension splices can be put on the connected ends of the moving rails, which will admit of expansion blocks of the proper size being put between the rails to fill up the space left by contraction.

BATTERED SWITCH RAILS.

39. Never take out one rail in a stub switch. When it becomes badly battered on the end, always take out at the same time the rails which meet it in the head chair. A good rail put in, and meeting a battered one, will soon be as bad as the one battered.

TIES UNDER MOVING RAILS.

40. The ties under the moving rails should be oak, sawed ties if possible, and as close together as they can well be tamped. None should be farther apart than 8 inches, and where a switch rod comes the ties should be closed up to within two and one-half or three inches of each other. This will keep switch rods in place. The object in having the ties close together under the moving rails is to keep the rails up to surface, and the cross rods square across the track in place; and in case of the trucks of a car or engine

getting off the track at any other place on a railroad, the ties being close together will support the wheels from sinking between them, and car or engine can more easily and quickly be put back on the track without danger of bending the tie rods.

BENT SPLICES.

41. When a foreman receives old steel rails for repairs he should always examine the splices, especially angle bar splices, and if they are bent in the center he should not use them again without straightening them.

LINING DISCONNECTED TRACK.

42. Foremen when lining track that has been washed out, or that has been disconnected at one end should never commence lining from the disconnected end. Always commence to line track from the end that is connected, and nearest to line, and work towards the end that is disconnected, and when you have moved it once, begin to line as before.

Some foremen with a large gang of men spend several hours of valuable time at a washout, in a fruitless attempt to bring into line the tail end of a piece of track, and when the men could not throw it, cut it into rail lengths and carry into place. This could have been avoided if track had been lined in the way stated above.

ORDERING TOOLS OR MATERIAL.

43. Track foremen, when ordering tools or material for use on the track in their charge, should not make requisition for more than the amount necessary of either kind. A surplus of tools or track material on hand, which there is no prospect of putting in service soon, represents their value in cash lying idle or going to waste.

KEEP MEN'S TIME CORRECTLY.

44. It is a notable fact that the best track foremen keep the time of their men and other accounts correctly, and do everything, as the saying goes, "in ship shape," while the reverse can only be said of foremen who are careless or slovenly. The want of an education is only an excuse, and a foreman, by devoting a little of his time evenings to study, can soon write a good hand, and learn enough of figures to do all that is required of him while in the position of track foreman.

DUPLICATE TIME BOOKS.

45. All track foremen should carry with them a duplicate time book, and note on the same day any loss of time, or time earned by any of the men working under them. Keep a journal of the work performed by them each day, always charging the proper number of days labor done by each of them at each separate kind of work. This record of time and work performed should be transferred at the end of each day to the regular time book and journal of work, which is sent to headquarters at the end of each month.

By following above instructions, a foreman will avoid making any mistakes, and will also be able to refer back to the time of his men, the kind of work done, and date of same, whenever called upon for information by his superior officers.

TRACK MATERIAL ACCOUNT.

46. When foremen receive track material of any kind, and it is loaded on cars or unloaded from cars by them, they should check over everything carefully and count the pieces, number of rails. ties, etc.; also note the brand or quality of the same, and take the number of the car. Keep this with your other ac-

counts, no matter whether you have orders to do so or not, as you may be asked to give information on the subject a month later.

PRINTED FORMS.

47. Track foremen should read and thoroughly understand the printed instructions on all blank forms which the railroad company requires them to use, when making their reports. Many foremen are too careless in this matter, often omitting to put down the answers to printed questions which it is almost impossible for them to miss seeing when filling out the form. Occasionally a foreman will put on his work journal the number of ties received during the month, and at the same time fail to give the number of ties used during the month, or the number on hand; while the latter questions are there on the journal, as well as the question, "How many ties received." Then the roadmaster must write him a letter a second time and instruct him what he should do and wait for an answer. It is just likely that the foreman spoken of above will be changing a rail in a side track, or doing some other kind of work, which could be put off or delayed without danger, for a week or two, when at that time he should have been examining his track after a heavy storm.

He has carried a time card in his pocket for months perhaps, and never informed himself that there was a rule on that time card which required himself and men to be out and examine the track on his section in stormy weather. Foremen of the kind mentioned do not hold a position long under any roadmaster, because they are not reliable; they need to be watched too closely and instructed too often in their duties.

SECTION FOREMEN'S REPORTS.

48. There is hardly a single railway company now in this country which does not furnish its foremen printed blanks for whatever reports they may be called upon to make. These blanks are generally made as simple as consistent with the nature of the report, and the foreman should study carefully the headings and printed instructions which will enable him to fill them out properly. It is most important that such statements are made at the proper time, that all entries are strictly correct and that they are made as concise as possible and in a legible manner. When such reports are completed they should be mailed to the proper officer. In regard to monthly statements of tools and materials received and used foremen will find it greatly to their interests if they retain a copy, of whatever they reported on hand the last of the month, so as to be able to fill the report for the succeeding month correctly. In fact it is advisable that each foreman keep a little book wherein he can note down all items of interest occurring on his section pertaining to the operation of the road. Such memoranda have often proven to be of great value to railway companies; besides that it enables foremen to make out duplicate reports in case the original has been lost or destroyed.

SHIPPING TRACK TOOLS.

49. Track foremen, when shipping tools or sending them to the repair shop, should always be particular to secure them in a neat package, so that it would not be possible for any of them to become separated or lost while in transit. The name and address of the repair shop foreman should be written plainly on the face of the shipping tag; on the back of the same tag the foreman should write his own name and address,

together with a request that the tools be returned to him when repaired.

A very convenient arrangement for securing tools together when shipping them, may be made by running a piece of chain through the tools or around them, and locking with a spring key after passing one of the end links through one of the other links of the chain. The key should be flat and just wide enough to fit the links in the manner mentioned. Fine soft wire is superior to twine for securing tools or for tagging them.

DISTANCE TO SET OUT DANGER SIGNALS.

50. Danger signals should be set out a distance of not less than three thousand five hundred feet in both directions from the point where the track is impassable for trains. This distance can be measured by counting one hundred and seventeen thirty-foot rail lengths, in the direction you are going to set out the signals; or when the telegraph poles are one hundred and fifty feet apart, the signals may be set out twenty-three telegraph poles distant each way from the point of danger.

When flagging at obscure places, or in the vicinity of descending grades, where it is difficult to stop a train, the distance to set signals must be doubled or the telegraph operator at the next station should be informed, so trains could be held until track was cleared and safe for their passage. Where there is a sufficient force of men, and it is practicable, the flagman should remain out with the signals until the track is repaired, or the train is stopped. In all cases during a snow storm, in foggy weather, or at night, the flagman must remain out with the signals until all danger is passed. When the track has been repaired, and

made safe for trains, the flags, torpedoes, or other signals should be removed immediately.

ALWAYS KEEP SIGNALS WITH YOU.

51. A track foreman should always keep on his hand car, ready for instant use, a full supply of torpedoes, red flags, or red lanterns, so that if any accident should render the track unsafe for the passage of trains, he would be prepared to protect them promptly. Flagmen sent out to patrol the track should not be allowed to proceed without having with them all the necessary signals to stop trains. The foreman should instruct them thoroughly in their duties, as he is responsible for them.

The first duty of a track foreman when he finds a dangerous place in the track, no matter whether it is on his section or not, is to set out stop signals at once; he should then go in the direction from which the next train is expected ,and report the trouble at the nearest telegraph office.

TIME CARDS AND RULES.

52. A track foreman should keep well posted on the time of all regular trains passing over his section. He should also study and understand thoroughly all the rules of the company, for which he is working, that relate to his work; and if in doubt about anything, ask an explanation of it from a superior officer. Read over all the rules on the time card at every time a new card is issued on your road.

NOTE OF FLAGS.

53. Whenever it is necessary for a foreman to use flags, instruct the man who goes to set the flag out, how to place it. Set slow flag on the engineer's side of train coming towards the place for which you are

flagging; set the flag slightly leaning so that most of it can easily be seen, and set it just far enough from the rail to clear engine and cars. A slow signal should be set out one-half mile or about ninety 30-feet rail lengths.

STOP SIGNALS.

54. When a reg flag or red light is used as a signal to stop a train, it should be set in the center of the track. Two torpedoes should be used together with the red signal day or night. The torpedoes should be placed sixty feet apart upon the rail, on the same side of the track, between the red signal and the approaching train.

LOOK OUT FOR SIGNALS.

55. Foremen should always look for signals on all passing trains. Another section of the same train which has passed, or a special, may be following close behind; and the track foreman and his men should be fully informed, and keep well posted as to the meaning of all signals displayed on passing trains.

OBSTRUCTING THE TRACK.

56. Track foremen should never attempt to use the track so as to obstruct a regular train. All work which would make the track unsafe for trains should be finished, and the track ready before a regular train is due from the nearest station in either direction from where you are working.

When working close to a station, foremen should have the track safe and clear before a train is due.

No work, which would make a track unsafe, should be done on the time of a delayed passenger train, except in case of emergency, and then a trusty man should be sent out in the direction of the expected

train, and take every precaution necessary to protect the train by proper signals. In case of bad weather, rain, snow or fog, he should be supplied with torpedoes and carefully instructed in their use.

REPLACE SIGNALS.

57. Trackmen finding danger signals along the track should leave them in the same position as found, and if the signals are injured so as to be unsafe, they should be replaced by good signals of the same kind, or a man should be left to guard the point. It is the duty of a track foreman, if he finds danger signals, to go forward and ascertain their cause, and to give assistance with his men, if the trainmen require their services.

INJURED SIGNALS.

58. All sign signals placed along the track for the guidance of trackmen or others (when injured or broken), should be repaired at once, and placed in position by the trackmen; and if they are destroyed or rendered useless, the foreman should at once make requisition on the roadmaster for new ones.

COMPLY WITH THE RULES.

59. Section foremen or others should use all signals strictly in compliance with the rules of the road governing their use. Never set out a danger signal at a shorter distance than that which is specified in the rules of the road as correct, because a serious accident may be the result, if a train cannot be stopped in time.

LOCATION OF WHISTLING POSTS AND SIGNS.

60. Station whistling posts should be set one-half mile outside the switches, not from the depot, and on the engineer's side, the right hand side of the track

to one approaching the station. Station mile boards should also be set one mile outside the switches, on the same side of the track as the whistling post. These two signs are used to warn the trainmen of the near approach to a station, that they may be able to get the train fully under control before reaching the station. The yard tracks at all railroad stations extend some distance each way from the depot. It will not do to place the signs above mentioned at the distance stated from the depot, for the reason that in big yards they would often be inside the switches.

Whistling posts for highway crossings should be set one-fourth of a mile from the crossing, on the engineer's side of the track. Whistling posts or signs of any description should never be placed in a cut if it is possible to avoid it. It is always better to increase or diminish the distance to get them out of the cut. The distance should always be increased where there is a down grade, or when the law requires certain signs to be placed a specified number of feet or rods. This rule should also apply on sharp curves. All signs, which have a painted cross board on top of a post, should be set with the cross board at right angles to the track, so that the sign can be plainly seen by the trainmen for whom it was intended. The cross board on highway crossing signs should be parallel with the track, so that persons approaching the track from either side on the wagon road can see and read the painted sign.

All posts and signs should be set firmly in the ground, and so far from the track, that if knocked down or blown over, they would not fall upon it. Never set any signs in a leaning or twisted position. Highway crossing signs should be set far enough away from

the center of the wagon road, so that wagons loaded with bulky material, such as hay or straw, would not strike the sign post or the cross arm at the top of them.

TRAIN'S DISRESPECT OF DANGER SIGNALS.

61. Section foremen should report promptly to the roadmaster any failure on the part of trainmen to honor danger signals set out by himself or his men. If an engineer fails to whistle for brakes, and runs at a high speed past the point for which you have set out a slow flag, or if a train runs past a dangerous place before stopping, for which you set out the necessary stop signals, you must report all the facts to the roadmaster without delay, giving the engine and train number, and the time they passed the place where you were working. Foremen should not overlook any neglect of duty by the trainmen in this matter. Always remember that the safety of trains, and the lives of passengers and employes depends in a great measure upon a strict compliance with the company's rules.

LOOK OUT FOR TRAINS.

62. Section foremen should always keep a sharp lookout for trains while working on track, while using hand cars, or while transferring material from one track to another on cars. Never trust too much in this matter to the men, as they are not held responsible for accidents. To be on the safe side, a foreman should always be expecting a train, then he will be prepared for all extra trains or specials, of which he has no previous notice.

ALWAYS BE PREPARED.

63. Whenever it is necessary for a foreman to go to a wreck or washout, or to assist at any kind of work

which calls him away from his own regular work, he should be prepared, having lanterns ready to light, tools all on the car, tape line in his pocket, etc. Don't start out half equipped with tools. When you find a place to fix up or repair, and there is need of tools, which you have not with you, you will have to send after them, perhaps delaying trains for an hour or more because of your carelessness. Don't go out on track and discover a broken rail, and at the same time find that everything necessary for repairing it is on hand except chisels, and they are at your tool house, seven or eight miles away. A foreman who is careless in these matters is generally so in everything else he does, although he may hold his position for a time. The roadmaster has him marked down as poor material, and will always remove him as soon as he can put a better man in his place.

HAND CAR AND TOOL HOUSES.

64. The hand car and tool houses of track foremen should be kept outside the switches at yards, or wherever is the most convenient place. They should be located so that the men can get to and from work without being delayed by trains standing on the tracks. Tool and hand car houses and track supplies of any kind should always be placed a sufficient distance from the track, so that they will not obstruct the view of the trainmen, or be likely in case of accident to fall on or near the track.

TELEGRAPH OFFICE REPORT.

65. When a section foreman's headquarters is located at a station, he should report at the telegraph office for orders and inquire for messages before going out to work every morning, and immediately after working hours in the evening.

REMOVING HAND CARS FROM CROSSINGS.

66. No material of any kind should ever be piled or placed on a highway where it crosses the track. Section foremen or others should never take off their hand or push cars and leave them on the highway or private wagon crossings unless it is absolutely necessary to do so to get out of the way of a passing train. The car should then be immediately put back on the track, and removed to a proper distance from the highway. Section foremen should provide places along their sections, at convenient distances not less than 100 feet from highways or crossings, where they can take off their hand or push cars, and leave them when necessary. Obstructing highways by leaving thereon track material, hand cars, etc., has been the cause of numerous accidents, and claims for damages against railroad companies.

THROWING SWITCHES.

67. Track foremen should not be in the habit of throwing switches for trivial reasons. Although it is the custom on most railroads to allow section foremen to carry a switch key, they should not abuse this right by unlocking and throwing switches to move a hand or push car without a load from one track to another, or to accommodate trainmen who should do this work themselves. Hand cars and push cars, with a light load, can as well be moved from one track to another, where the rails come close together, without throwing the switch. Men employed on the section should not be trusted to throw a switch, except in the presence of the foreman. When a switch has been thrown on a side track, the person throwing it should not leave it until after throwing the switch back again on the main track and locking it.

Any foreman who would throw, or allow others to throw a switch from the main track, and leave it in that position while performing a piece of work, or until it suited his convenience to throw it back, should be discharged; and he would be criminally liable if any accident should happen through his carelessness. Those intrusted with the operation of switches cannot be too careful.

LEAVING HAND CARS ON TRACK.

68. Some track foremen have a habit of leaving hand or push cars on the track, while cutting weeds or doing other work which requires frequent moving from place to place. This should not be done. The main track should be kept clear at all times, except when trackmen must occupy it to do necessary repairs; at such times or when moving loads of material on cars, foremen should protect themselves with proper danger signals.

Foremen should not leave hand cars on side tracks as they are liable to be smashed by trains switching, and cause a wreck at the same time.

LOANING TOOLS, CARS, ETC.

69. Track foremen should never loan to persons outside of the company's service any tools, hand car, velocipede car, push car, or track material of any kind which is intrusted to their care, without permission of their superior officers. Foremen themselves or their men should not use hand cars, velocipede cars, etc., on the track outside of regular working hours, unless in the company's service, or with permission from the roadmaster.

Foremen who adhere strictly to this rule are very seldom requested by outside parties to grant them any privileges, and thereby save themselves annoy-

ance. Track foremen should remember that company material of any kind, no matter how valueless it may appear to them, is still the company's property; and that they have no right to appropriate it for their own use, or to sell it to others, without authority from their superior officers.

DIFFERENT VARIETIES OF TIES.

70. On a railroad where different varieties of ties are used in the track, the softer kind of wood should be used in straight track, and the hard wood ties should be used in the curves, and in sags between heavy grades where the speed of trains is very fast. If hard wood ties can be procured for a curve track they should not be mixed with soft wood ties in the same track, because the rails will in the course of time cut a bed in the soft wood ties, and thereby affect the surface of the track. At the end of bridges and under switches are also good places to use hard wood ties, where they can be furnished for that purpose. White cedar is the best soft wood tie; white oak the best hard wood tie.

THE PLACE FOR TOOLS.

71. Foremen should bring home every night and put in the tool house all tools which they have been using on track during the day. Never leave tools out on the section. Unscrupulous persons who live near the track or who may pass along there are very apt to appropriate any tools which they find along the track. Any loss of track tools should be reported by foremen to the roadmaster.

CUTTING STEEL.

72. Whenever it is necessary to cut steel rails, track foremen should instruct the men how to do it properly.

All steel rails should be cut as accurately as possible as to length, and allowance for expansion should be deducted from the length of the rail. No careless work should ever be allowed, such as cutting the rail one inch or more short of the proper length.

The line of the chisel cut around the rail should be continuous and square across the rail. Iron rails, as a general rule, need to be cut deeper than steel before they will break off. Hard steel, if cut deep, is liable to bcome tough at the cut, and will sometimes break off on either side of the cut, leaving a bad, unshapely end on the rail. To break off a rail at the cut, lift up the rail at the end nearest to the cut, and let the cut place fall over a piece of rail laid on a tie, or something solid across the track rails. Short pieces to be cut from rails may be broken off with the sledge. When cutting rails trackmen should not use a spike maul to strike the chisel, because this destroys the face of the spike maul, and splits pieces from the head of steel tools, making them worthless in a short time. A good sledge made on purpose for striking hard steel tools should be one of the tools on every section, and should be taken in preference to any other tool of the kind whenever necessity requires its use.

THE BALLAST IN YARDS.

73. The yard track at all stations inside the switches should be dressed off level with the top of the ties, both inside and outside of the track rails. When there is enough ballast the shoulder should be level and of sufficient width to allow trainmen or passengers room to walk along outside the ties. Where yard tracks are close together no rubbish, or obstructions of any kind should be placed on the space between them or allowed to remain there.

EXECUTE PROMPTLY.

74. When the foreman receives an order from the roadmaster to do any special piece of work, he should do it at once, and finish it up in the manner in which he is instructed. It is of the greatest importance that track foremen adhere strictly to this rule. Never let work wait to suit your convenience, nor do any work in a way contrary to that in which you are ordered to do it.

PROTECT AGAINST FIRES.

75. In the fall of the year when the weeds and grass along the right of way have become dead and dry, section foremen should take every precaution to protect the company's property, and that of persons living near the track, from damage by fire. Fire started by sparks from locomotives, or from other unknown sources should be looked after at once and extinguished. Do not cease your efforts until you are sure all danger is past. All wooden structures, bridges, culverts, etc., should be examined as often as you pass them and any combustible matter which may be close to the timbers should be removed. Be particular, when burning rubbish or grass along the right of way, to always work with a favorable wind. Run no risks, and if you see a doubtful smoke along the track, take your men, go to it at once, and find out what has caused it.

REPORT STOCK KILLED.

76. All stock killed or injured, and found lying on the right of way by the foreman, should be reported promptly to the roadmaster. Section foremen should always report the stock killed or injured. It is the duty of foremen to make an examination of the body of the animal found, find the owner if possible, and get the

age and cash value of the animal. If it was struck by a train, give engine number, train number and time of the accident, if you know it. In your report give all other information which is likely to be of any value to the company you are working for. If the owner of a dead animal does not remove it from the right of way, the section foreman should take his men and bury the carcass after investigating the cause of accident, etc.

Foremen have no right to appropriate to their own use (or to allow others to do so) the carcass or hide of any animal killed along the track.

DAMAGE BY FIRE.

77. When property along the right of way has been destroyed or damaged by fire, the section foreman should go to such place at once, examine the ground thorougly, measure the distance from the center of the track to where the fire started, find the value of the property destroyed, make out an itemized estimate in his report; and also state the direction of the wind when the fire was burning, and give a true account of everything as far as he knows. Do not accept the statement of others until you know them to be correct.

BE CAREFUL OF MATERIAL.

78. When a track foreman lays or extends a piece of track, as soon as he has finished the job he should have every loose spike, bolt, splice, etc., picked up and taken care of. Track material lying around where a gang of men have been working is very good evidence that the foreman is careless about his work and wasteful of the company's property. If loose bolts or spikes were picked up and taken care of until used, many thousands of dollars would be saved for the company in a year.

Never allow old iron taken out of track, old ties, broken brakes, links, pins, etc., to accumulate on your section. Bring them into the station and ship to the points designated by the roadmaster, all except what is needed for use on your section.

DO FIRST WHAT NEEDS TO BE DONE.

79. A track foreman should always have his work planned ahead. By giving close attention to the track, as he passes over it daily each way, a foreman will always be able to see what needs to be repaired most, and it is hardly necessary to say here that such work should be done at once. Do not ride over the same low joint every day, a joint one-half inch out of gage or line, or pass the same broken joint tie or bolt hanging loose in the splices expecting to fix such places the next week or waiting until the roadmaster calls your attention to these things. The longer you wait, the more these little odd jobs increase in number, and at about the time you have set to do them you are called off to some place else. The work still increases during your absence, and in this manner things go on the year round. You are always behind, always worried; you think the roadmaster hard because he urges you to hurry; you make excuses for yourself, as for instance, that you were putting up a nice piece of track somewhere else on the section. But always remember that if you had ten miles of the best track in the country, all good track except one rail length, and that rail was dangerous, the balance of your section, no matter how good, would not save a train from getting wrecked, nor you from the blame that would justly fall upon you. In no other line of business does the old saying apply with greater force than on a railroad:

"Never put off till to-morrow what should be done to-day."

HOW TO DO WORK.

80. Experience will teach a foreman that the secret of keeping a good track on his section lies in doing all work well. Slight no work. Do not surface up track to make a big show for the present, but surface it as fast as it can be done to make track that will remain good a long time. Very smooth track, well lined and gauged, will stay good sometimes for years without much repairing. On the other hand, track that might be called good, with an occasional slight dip in the surface, if there is much traffic over it, will soon be bad track; because, where quarters or joints are only one-quarter of an inch low after the track is surfaced, the weight of an engine or loaded cars strike such low places with great force, and gradually increase the depression until the track becomes very rough and dangerous. If not cared for, low places in track knock out of gauge and line besides getting low. The same method of doing work will not answer always. Foremen should adopt a method of doing work that will give the best results with the kind of material furnished.

If there is only dirt for ballast, don't always be telling what good track you could have with gravel or rock, but see how good a track can be made with dirt for a ballast.

FOREMEN ON DUTY.

81. When on duty, the foreman should always be with his men and assist them in doing the work. It is his duty also to instruct his men by word and example as to the proper manner of performing all the different kinds of work in which they are together engaged.

ADOPT THE BEST METHOD.

82. If you can improve on the old method of doing any kind of work, when you are not satisfied with the results of a trial, adopt a new plan. When you do any kind of work on track, and it does not give satisfaction, always try to find the remedy for its defects. Do not say it can't be done, but remember that a man who finds himself in a difficult position, if he has good judgment and a lively brain, can work out some of the most difficult problems without any previous knowledge of them. Never take a slow method to do any kind of work that you can do as well in a quicker way. Don't forget that the world moves, but move with it. Try to learn something from the experience of others who are successful in the same profession as yours. A trifle of time gained soon amounts to a day, month or year, if multiplied many times. Take for example two men spiking track, one strikes across the rail when his partner tacks the spike in the tie, then both finish driving their own spikes. Another man tacks his spike, and does all the driving on it himself without striking across the rail. On every spike he drives, the first man gains two motions which the second man loses, and at the end of a hard day's work the first spiker will be a long distance ahead of the second man, and with considerable less labor; although to the inexperienced onlooker there would be no perceptible difference in their methods of working.

Take for another instance the case of two foremen putting new ties in the track. One removes all the dirt or ballast from the center of the track to the outside of the rails in order to get a number of ties into track at once; the other foreman moves the material in the center of track back upon the new ties as fast as

he puts in two or three; and by that method the latter foreman saves himself and his men the labor of shoveling many yards of ballast from outside the track rails to fill the center of the track. To bring a section of track up to anything like perfection, the foreman in charge of it must look closely after all the work in its minutest details, and allow nothing to go undone which would contribute towards improving the track. None but careless foremen will line up one side of a track well and then leave it without taking the kinks out of the gage side at the same time. A careless foreman will put a new tie into track without taking up to surface a low joint close to it. He will cut weeds past a joint with a bolt broken out of it without putting in a new bolt. He will make a trip over the section, and never notice a break in a fence, or if he does note it, will wait until he is notified by the roadmaster to fix it. It is likely that you will find the same foreman surfacing a piece of track without using a spirit level on it. Such a man is not fit to make a good laborer, much less a foreman; and the piece of road in his charge will soon run down if he be not discharged and replaced by a foreman who has a desire to improve the track whenever he does work on it. The work of a careless foreman puts the roadmaster to watching him, because he informs on himself every day, while the careful, industrious foreman makes a good, permanent job wherever he works, and the result is a first-class track where recently may have been a very rough section.

CHAPTER XXIII.—MISCELLANEOUS.

WORK TRAIN SERVICE.

1. Trackmen who are in charge of work train gangs should make it their business to keep the men employed whenever the train is delayed in the regular work. There is always plenty to do along the track at any point. A good foreman will have his work laid out ahead, so there will not be any delays, except those which are unavoidable.

When possible, it is always best to put a good practical workman in charge of a gang of men on a work train. It is poor economy to have an inexperienced trainman in charge of a train and a large crew of men, as is often the case. When the position of foreman over the men and conductor of the work train is held by one person, the preference should be given to a trackman if competent to run the train, or to a man who has some experience in both branches of the service.

TO WHOM RESPONSIBLE.

2. Work train conductors and foremen of gravel pits, or of steam shovel outfits, should receive their working orders from, and be strictly responsible to the roadmaster, on whatever division of the road they are working at the time. Work train conductors should report daily to the roadmaster on blank forms furnished for that purpose, and, if required, they should also report to the division superintendent.

They should also make a lay up report to the train dispatcher every evening after quitting for the day, and inform him where the train will work the following day.

Work trains should always lay up over night at a telegraph station.

Conductors of work trains should see that the axle boxes of all the cars in their trains are properly packed, and oiled as often as necessary, and that all defects in rolling stock or track, where the train is working, are repaired. All accidents to cars, and anything which would interfere with or delay the work should be reported promptly to the roadmaster or superintendent, so that they may be quickly remedied.

CARE OF INTERLOCKING SWITCHES.

3. This branch of railroading is extremely intricate, and requires in the majority of cases a special department to handle it; but after the plant is erected and connected up the trackman's troubles commence.

Interlocking, as the name implies, is something that is locked together with something else; or, in other words, if the switches controlled by the tower are set for one route, this will be indicated by the signals, and no change can be made until all the signals are back to the danger position, and then the switches can be thrown and the indications given accordingly.

There are two general forms, one in which the switches, etc., are thrown by hand, or the manual; the other where the force to throw switches and signals is compressed air, which is operated by valves controlled by electricity; this is known as the Electro-pneumatic System.

The simplest form of interlocking is where one switch stand is so connected that it operates the switch

leading from a siding to the main line, and also a derail switch on the siding.

Next in simplicity is the Vernon-Ellis hand interlocking system. By this method movable point frogs in slip switches are so protected that they cannot be fouled while being thrown.

In relation to placing of insulated joints in track, unless provided with a base plate, they should not be attached to frogs or heels of switches; if they are, these will be greatly weakened.

One of the best insulated joints at present for this purpose is the Weber, illustrated in Figure 63. It is seen that the joint consists of two wooden fishplates fitting between head and flange of rail, securely bolted through web to a steel angle; the horizontal flange of this angle acts as a base support for the rails while the vertical flange provides a rigid support for the bolts, which keep the wooden fishplates forced up to the rails, thus insuring true alignment of rails. A thickness of fiber is laid on inside of steel angle to secure absolute insulation. The bolts are insulated by use of brass thimbles with a fiber inside. More Weber Insulated Joints are in use on American roads than any other kind.

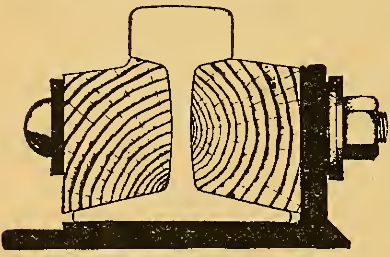

FIG. 63.

In using the track electric circuit in order to insure carrying the current from one rail to another, it is necessary to connect same by wires. To protect these they should be placed behind the angle bars, and trackmen

should carefully handle such joints so as not to break these connections. If it is necessary to do any work by which these will be disturbed so as to break the connections, the proper authorities should be notified at once.

After the plant has been put in place a considerable portion of the working of same falls on the trackmen. All running parts should be carefully cleaned and oiled daily. The bolts at heels of moving points should be so adjusted that an additional strain will not be brought on the levers in the tower. A very good method of accomplishing this is to use an angle bar, which is slightly bent, at the heels of movable point frogs and

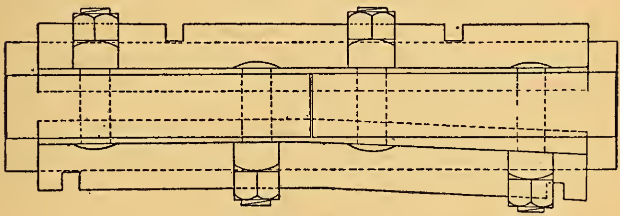

FIG. 64.

switches. This can best be described by reference to the sketch, Fig. 64.

In this the inside of the bar is bent from the middle toward the end of the moving point an amount equal to the throw at the end of the bar; then very long bolts are used with lock nut. This does away with any hinged device, and is absolutely safe. Also stops should be used at several places on the side of the moving point furthest from the stock rail, so as to do away with any lost motion.

When slip switches are used it is better to have the joints at the heels of all moving points come on a tie, these acting as solid supports.

All ties should be tamped where interlocking is used, so as to prevent any settling; and no connections should be attached to the ties except where absolutely necessary, as this renders renewals and changes much easier, there being nothing to disconnect or replace.

The adjustment of all point rails should be given careful attention, so as to be sure that they always stand up to the stock rail.

When connecting up switches with piping from towers, the person in charge should ascertain that the track is to proper grade and not liable to settle before the foundations for pipe lines are set, then these can be placed to a proper height.

It is in times of a snow storm that the trackman is kept busy with switches thrown from a tower. All snow must be kept cleaned from the points, and also from all cranks, detector bars, locks, etc., the piping must be kept cleared, and all wires leading to signals freed from snow. In order to do away with the greater portion of this expense, where possible the piping and wires should be covered by boxing.

In heavy snow storms trains should be cautioned to pass over switches, which are interlocking, with care, as it is often advantageous to disconnect certain parts to keep the plant running. For instance, detector bars being so long, get filled and thus render themselves hard to move; these can be disconnected. If the locks and switches, owing to the severity of the storm, are rendered useless from the tower, it is to the foreman's advantage to have these disconnected also, and throw the switches by emergency stands. This is an extreme case and should only be resorted to when a tie-up is imminent; and as trains then have to move on a hand signal they should use great precaution. These stands should be made as small and compact as possible and

set up on ties ready to be connected in times of emergency.

To decrease the expense account in snow storms, it is possible to use compressed air to clean the switches. This is especially recommended at electro-pneumatic stations. This method of getting rid of the snow is in the experimental stage at present, but great results may be expected in the future.

There are places where the accumulation of snow during a storm, from piling it up, etc., often attains such size as to block traffic. At such points a pit can be constructed with steam pipes inside, so as to melt the snow; this will necessitate using men with hand-barrows to carry it from the places where it has been heaped up, to the pit. In the bottom of this latter is a drain to carry off the water. In this arrangement the steam pipes should be on an incline, so as to avoid the possibility of water lodging in them and freezing; and also the drain should always be kept clear.

TRACK INSPECTION.

4. There should be a well organized system of track inspection in force on every railroad, and it should be made efficient in proportion to the amount of traffic and the condition of the track.

On roads where only ten trains a day or less pass over track, an arrangement could be made to have the section foreman, on days on which his work would not call him to the end of his section, send a man over to examine the track from whatever point the gang were working and whenever there would be economy in it, the hand car could be run to the end of the section in preference to sending a man over on foot.

It is bad policy to force the section foreman to go over all his track daily on long sections, during the

summer months, when there are but few trains and plenty of work for him to do with a small crew of men. But in case of storms all track should be examined day or night.

When a railroad is double tracked, or there are a large number of trains daily over a single track, a regular track-walker should be employed, whose business would be to go over the whole section once a day in each direction, and to be required to report to the section foreman, and also to the station agent or operator, when there is a depot at both ends of section.

The track-walker should so time his passage over the section as to be able to see all the track or at least the most dangerous points, a short time ahead of passenger trains; and when most of the trains run at night, his examination of tracks should be made altogether at night, the section crew or another track-walker looking after it in the daytime.

During the winter months, when the ground is frozen solid, a rule obligating the section foreman to see all his section daily should be strictly enforced, because at that time of year the danger of accidents is greater, and the amount of general track work that can be done is much less than at other seasons of the year.

During extremely cold or stormy weather is just the time that track most needs to be examined, and in order to insure inspection of track at least once a day, it is recommended that, when it is not possible to run a hand car, the section foreman with one of his men be allowed to ride one way on trains, against the storm, to the next station or to the end of his section and return back over the track on foot, carrying what

signals and tools would be necessary in case of an emergency.

The conditions are so varied on different railroads and sometimes on small divisions of a railroad that each company can best organize a system of track inspection which in the judgment of its officers would be best suited to its wants. The foregoing methods are only offered as suggestions from which something more useful might be designed.

LONGER RAILS.

5. Why should the length of a track rail be only 30 feet if it can be demonstrated that there is economy in using a rail 36 feet in length or longer? A rail 12 yards long, 80 pounds to the yard, weighs less than 1,000 pounds, and as it does not require to be handled a second time until it has laid in the track a number of years, there can be but little objection to the increase in the weight of a rail with regard to the handling; and, further, when such a rail is taken out of the track after long service, to have the battered ends sawed off, it would still make a good, long rail; far ahead of the cut steel rails which are used second hand nowadays.

The use of rails 12 yards long will take one-sixth of the joints out of track, which means one hundred miles of joints out of a track six hundred miles in length. This is no small item to consider, saving, as it does, 3,500 pounds of angle bar splices to the mile, and 360 bolts, not including those bolts used to replace broken ones during the life of the rails. There are also 360 nut locks saved per mile, besides the labor required to put on these fastenings and keep the track in repair at the joints. Taking all things into account, a big saving could be effected annually in the cost of main-

taining any ordinary main track, and the amount which could be saved in the first cost would be more than a million dollars in laying all the tracks of one of the largest railroads. Every trackman knows that the rail joint requires more labor than any other part of the track, and for this reason alone it is advised making their number less. When considering the question, whether it is advisable to use a longer track rail, the only objection of any consequence that could be raised, would be on account of expansion and contraction, and the extremes of temperature of the locality in which the rails are to be laid will determine to a great extent what should be the limit to the length of the track rail if used with the present joint fastenings.

Investigation should be made to find out what is the greatest possible length of rail that may be used without injuriously affecting the track. A rail thirty-six feet long can be used with the joint fastenings now in use, in more than half of the United States, and a much longer rail may be used; for instance, below the frost line in the Southern States.

The theory of a continuous track with the joints welded by electricity, and the expansion and contraction controlled by split rails put in at intervals along the track, has many objections, as have also some other new methods which were proposed as a means of lessening the number of joints in tracks, while but few, if any, objections of any consequence can be brought against the method advocated in this paragraph, and it seems there can be no question that such a rail will make a smoother riding and a safer track than one 30 feet long, and effect a great saving in first cost, labor and maintenance. Experiments of rails 45 and 60 feet long have been made and proven satisfactory as from the point of practicability.

HINTS TO SECTION FOREMEN.

6. Track foreman should be respectful to his superior officers without being servile, and when talking or writing to them he should show a confidence in himself without making too much of an exhibition of self-conceit or stubbornness, either of which will only be awarded with their ridicule or contempt. A man who is placed over other men should have a will power strong enough to control them and maintain his authority without being either abusive or profane. To bulldoze an inferior is not the way to either instruct him or gain his respect.

Foremen who can keep good men, and secure more men when wanted, are more valuable to a railroad company than those who frequently discharge men and who seldom have help when it is needed.

Try to gain the respect of your men and you will have faithful workers. To do this it is not necessary that you be too familiar with them.

If you have a man working for you who will not do the work as you instruct him, discharge him and get some one who will. But do not work along in a groove, and think you have learned it all, and if any of your men suggest something which you know to be an improvement do not be ashamed to adopt it.

Track foremen should learn the habit of studying out the best method of doing each piece of work on which they are engaged, and when practicable have the work planned out beforehand. The mind can often do more than the hands.

A good track foreman will have a keen interest in his work, and be ambitious to show good results as well the last day he works for a company as when he was first promoted from the shovel.

Foremen who are not prompt in executing the orders of the roadmaster, and who often do work in a way contrary to that in which they have been instructed, seldom hold a position long on any road. This kind of men, together with that class which frequent saloons and get drunk occasionally, constitute about nine-tenths of the section foremen who are discharged for cause. Roadmasters very seldom discharge a foreman for his want of knowledge about some particular piece of work, and they are always willing to give information as to the best method of doing work when asked for it. Whenever a track foreman begins to think his work is too hard and his pay is too small, or that the officers of the road are not using him right, he becomes careless and loses all interest in the work. That man should quit at once and go hunt a job in some other place, where he might be better satisfied and appreciated. Every track foreman should make a continued effort to elevate his profession and make it respectable. Be sober, honest and industrious and you will be successful.

SECTION RECORD.

7. The attention of trackmen generally, and especially section foremen, is called to the importance of keeping a record of everything connected with the piece of track in their charge. Every foreman should know the length of his section, the amount of straight and curve track, the degree of every curve, the different brands of steel or iron rail, how much of each and when laid. He should also know the number of cuts on his section and the amount of snow fence, if any, on each cut; the bridge and culverts numbers and highway or railroad crossings, and the distance they are from his headquarters; and many other facts of importance

which are very valuable to assist a man in organizing work, and making comparisons, also that he may be in a position to answer questions of his superior officers as to location of places and things without the necessity of making special examinations when the time cannot well be spared. The following example illustrates a simple form for condensing the information referred to, and is a handy way for foremen to write it out on the pocket memorandum:

SECTION NO. 10.

Length of Section ....6 miles, 1,000 feet.
" " north side track.............. 1,600
" " house track................. 1,800 "
" " south track.................. 1,000 "

BRIDGE NO.	NO. OF BENTS.		LENGTH OF SPAN.	DISTANCE FROM STATION.
50 51 52	3 8 Iron		30 feet 100 " 120 "	2 miles 2½ " 3¼ "
CULVERT NO.	BOX.	STONE.	IRON PIPE.	DISTANCE FROM STATION.
186 187 188	 1	1	.... 1	1½ miles 1¾ " 2½ "
CUTS, LENGTH IN FEET.	HEIGHT ABOVE RAIL.		PANELS OF SNOW FENCE.	DISTANCE FROM STATION.
One 352 " 488 " 1260	4 feet 8 " 9 "		22 30½ 89	3 miles 3½ " 4 "
STEEL RAIL, AMOUNT.	WHEN LAID.		BRAND.	EXTENDS FROM STATION.
4 miles, 500 ft. 2 miles, 500 ft.	1895 1899		N. C. R. M. Co. 75 lbs. Crawshaw 85 lbs.	West—From Steel to End of Section.

AVERAGE DAY'S WORK FOR ONE MAN.

7. The amount of labor given below can each be performed by one good man in one day, and will serve to show comparatively the relation existing between the labor of one man, and that of a large gang of men, at any of the different kinds of work specified:

ONE MAN CAN

Lay to place on a grade one-eighth of a mile of ties;

Spike one-tenth of a mile of track laid on soft ties;

Spike one-fourteenth of a mile of track laid on hard ties;

Splice and bolt one-sixth of a mile of track;

Clean with a shovel one-eighth of a mile, average weeds;

Unload ten cars of gravel;

Unload eight cars of dirt;

Load upon cars eighteen to twenty-four yards of gravel;

Load upon cars twenty to twenty-five yards of dirt;

Load coal into buckets for engines, 15 to 20 tons;

Unload coal cars into shed, 25 to 30 tons;

Put in a dirt ballast track twenty new ties;

Put in a gravel ballast track fifteen new ties;

Put in a stone ballast track eight to ten new ties;

Do labor equal to ballasting sixty feet gravel track;

Do labor equal to ballasting thirty-five feet stone track;

Chop two cords four-foot wood;

Make fifteen to twenty-five hard wood ties;

Make thirty-five to forty soft wood ties;

Sixty men can lay one mile of track in a day.

TRACK BOLTS.

8. The number of bolts in a 200-pound keg of track bolts, Hex. nuts $1\frac{3}{8}$x$\frac{3}{4}$, is as follows:

SIZE OF BOLT.	NO. PER KEG.	NO. OF BOLTS REQUIRED FOR ONE MILE OF TRACK.	
		4 BOLTS TO JOINT.	6 BOLTS TO JOINT.
$3\frac{1}{2}$ x $\frac{3}{4}$	240	6 Kegs	$8\frac{4}{5}$ Kegs
$3\frac{3}{4}$ x $\frac{3}{4}$	227	$6\frac{1}{5}$ "	$9\frac{1}{2}$ "
4 x $\frac{3}{4}$	218	$6\frac{1}{2}$ "	$9\frac{2}{3}$ "

Bolts of the size here given are the ones now most generally in use on standard gauge railroads.

SPIKES.

9. Owing to the difference in the shape of the heads and the general form of the body of the spikes manufactured by the different companies who furnish railroad supplies, it is not possible to make a table which would show the correct number of spikes, of all sizes, per keg of 150 or 200 pounds weight. The spikes most commonly used to spike narrow gauge and standard gauge tracks are as follows:

SIZE.	AVERAGE NO. PER KEG OF 200 LBS.	WEIGHT PER YARD OF RAILS USED.	NO. OF KEGS PER MILE.
4 x ½	600	25	18
4½ x ½	525	35	21
5 x ½	448	35 to 45	24
5½ x $\frac{9}{16}$	378	45 to 75	28

To ascertain the number of spikes in a keg, for any size of spike not mentioned in the table: Divide the full weight of a keg of spikes, less the keg, by the weight of one spike, and the quotient will be the number of spikes contained in the keg.

NUMBER OF SPIKES.

A 200-pound keg contains on an average 378 spikes, 5½x9-16.

The following table shows the number of ties, 30-foot rails, and feet of track that can be spiked in full, by different numbers of kegs of spikes, 5½x9-16 inches:

NO. OF KEGS 5½ x $\frac{9}{16}$.	NO. OF TIES.	30 FOOT RAILS.	FEET OF TRACK
1................	94½	6 $\frac{1}{3}$	190
2................	189	12 $\frac{1}{2}$	380
3................	283½	18$\frac{13}{16}$	570
4................	378	25 $\frac{1}{2}$	760
5................	472½	31 $\frac{1}{2}$	945
6................	567	37 $\frac{5}{6}$	1135
7................	661½	44$\frac{1}{10}$	1330(¼m)
14................	1323	88 $\frac{1}{5}$	2640(½m)
28................	2646	176 $\frac{2}{5}$	5280(1 m)

There is no allowance made in the above table for broken spikes. The number is often larger when lay-

ing new track, and foremen may find it necessary to order one or more kegs than the amount given in this table.

TONS OF RAILS REQUIRED FOR ONE MILE OF TRACK.

Rule:—To find the number of tons (2240) of rails to the mile: Divide the weight per yard by 7, and multiply the quotient by 11. Thus, for 56-pound rail, 56 divided 7 equals 8, multiplied by 11, equals 88 tons of rails to one mile of single track.

Weight of Rail Per Yard.	Tons Per Mile.		Weight of Rail Per Yard.	Tons per mile.	
Pounds.	Tons.	Pounds.	Pounds.	Tons.	Pounds.
12	18	1920	64	100	1280
14	22		65	102	320
16	25	320	68	106	1920
18	28	640	70	110	
20	31	960	72	113	320
22	34	1280	75	117	1920
25	39	640	76	119	960
26	40	1920	77	121	
27	42	960	78	122	1280
28	44		79	124	320
30	47	320	80	125	1600
33	51	1920	81	127	640
35	55		82	128	1920
40	62	1920	83	130	930
45	70	1600	84	132	
48	75	960	85	133	1280
50	78	1280	86	135	320
52	81	1600	87	136	1600
56	88		88	138	640
57	89	1280	89	139	1920
60	94	640	90	141	960
62	97	960	91	143	

12. NUMBER OF CROSS-TIES REQUIRED FOR EACH MILE OF TRACK.

DISTANCE FROM CENTRE TO CENTRE.	NO. OF TIES.
1 foot 6 inches..................................	3520
1 foot 9 inches..................................	3017
2 feet	2640
2 feet 3 inches..................................	2348
2 feet 6 inches..................................	2113
2 feet 9 inches..................................	1921
3 feet	1761

13. LENGTH OF RAIL AND NUMBER OF JOINTS, SPLICES AND BOLTS FOR EACH MILE OF TRACK.

LENGTH OF RAIL.	NO. OF RAILS OR JOINTS.	NO. OF SPLICES.	NO. OF BOLTS 4 PER JOINT
20 feet	528	1056	2112
21 "	503	1006	2012
22 "	480	960	1920
23 "	459	918	1836
24 "	440	880	1760
25 "	422	844	1688
26 "	406	812	1624
27 "	391	782	1564
28 "	377	754	1508
29 "	364	728	1456
30 "	352	704	1408
31 "	340	680	1360
32 "	330	660	1320
33 "	320	640	1280
34 "	310	620	1240
35 "	302	604	1208
36 "	292	584	1168

14. WEIGHT PER YARD, PER 30 FOOT RAIL, AND NET TONS PER MILE.

No. lbs. per yard of rail.	Weight of a 30-foot Rail.	Tons of Iron or Steel per Mile of Track.		No. lbs per yard of rail.	Weight of a 30-foot Rail.	Tons of Steel per Mile of Track.	
		Tons.	lbs.			Tons.	lbs.
5	50	8	1600	69	690	121	880
30	300	52	1600	70	700	123	400
35	350	61	1200	71	710	124	1900
40	400	70	800	72	720	126	1440
45	450	79	400	73	730	128	960
50	500	88		74	740	130	480
51	510	89	1520	75	750	132	
52	520	91	1040	76	760	133	1520
53	530	93	560	77	770	135	1040
54	540	95	80	78	780	137	560
55	550	96	1600	79	790	139	80
56	560	98	1120	80	800	140	1600
57	570	100	640	81	810	142	1120
58	580	102	160	82	820	144	640
59	590	103	1680	83	830	146	1160
60	600	105	1200	84	840	147	1680
61	610	107	720	85	850	149	1200
62	620	109	640	86	860	151	720
63	630	110	1760	87	870	153	240
64	640	112	1280	88	880	154	1760
65	650	114	800	89	890	156	1280
66	660	116	820	90	900	158	800
67	670	117	1840	100	1000	176	
68	680	119	1365				

One pound more or less in weight per yard of rail makes a difference of one ton and 1,520 pounds in the weight per mile. The table No. 14 will enable any track foreman to see at a glance the exact amount of iron or steel required per mile of track, if he knows the weight per yard of rail which he is using, or about to order for his division. For smaller amounts than one mile (if using 30-foot rails) multiply the number of rails required by the weight of rail given in second column, and divide 2,000 pounds to reduce to tons.

15. LUMBER TABLE—SHOWING NUMBER OF FEET, BOARD MEASURE, CONTAINED IN A PIECE OF JOIST, SCANTLING OR TIMBER OF THE SIZES GVEN.

SIZE IN INCHES.	LENGTH IN FEET OF JOISTS, SCANTLING AND TIMBER.												
	12	14	16	18	20	22	24	26	28	30	42	44	45
2x 4.........	8	9	11	12	13	15	16	17	19	20	28	29	30
2x 6.........	12	14	16	18	20	22	24	26	28	30	42	44	45
2x 8.........	16	19	21	24	27	29	32	35	37	40	53	58	60
2x10.........	20	23	27	30	33	37	40	43	47	50	70	74	75
2x12.........	24	28	32	36	40	44	48	52	56	60	84	88	90
3x 4.........	12	14	16	18	20	22	24	26	28	30	42	44	45
3x 6.........	18	21	24	27	30	33	36	39	42	45	63	66	68
3x 8.........	24	28	32	36	40	44	48	52	56	60	84	88	90
3x10.........	30	35	40	45	50	55	60	65	70	75	105	110	113
3x12.........	36	42	48	54	60	66	72	78	84	90	126	132	135
4x 4.........	16	19	21	24	27	29	32	35	37	40	56	58	60
4x 6.........	24	28	32	36	40	44	48	52	56	60	84	88	90
4x 8.........	32	37	43	48	53	59	64	69	75	80	112	118	120
4x10.........	40	47	53	60	67	73	80	87	93	100	140	146	150
4x12.........	48	56	64	72	80	88	96	104	112	120	168	176	180
6x 6.........	36	42	48	54	60	66	72	78	84	90	126	132	135
6x 8.........	48	56	64	72	80	88	96	104	112	120	168	176	180
6x10.........	60	70	80	90	100	110	120	130	140	150	210	220	225
6x12.........	72	84	96	108	120	132	144	156	168	180	250	265	270
8x 8.........	64	75	85	96	107	117	128	139	149	160	224	234	240
8x10.........	80	93	107	120	133	147	160	173	187	200	280	294	300
8x12.........	96	112	128	144	160	176	192	208	224	240	336	352	360
10x10.........	100	117	133	150	167	183	200	217	233	250	350	366	375
10x12.........	120	140	160	180	200	220	240	260	280	300	420	440	450
12x12.........	144	168	192	216	240	264	288	312	336	360	504	528	500
12x14.........	168	196	224	252	280	308	336	364	392	420	588	616	630
14x14.........	196	229	261	294	327	359	392	425	457	490	686	716	735

16. SOME USEFUL NUMBERS.

Ratio of circum. of circle to diam. = 3.1415926.
Dyne in grammes = .00102.
Poundal in dynes = 13825.
Erg in gramme centimetres = .00102
Foot-pound in kilogramme-metres = .13825.
Kilogramme-metre in foot pounds = 7.23308.
Foot-poundal in ergs = 421390.
$\sqrt{2} = 1.4142.$
$\sqrt{3} = 1.7320.$
$\sqrt{5} = 2.2361.$
A cubic foot of water at 4° C. weighs in pounds = 62.425.
A cubic foot of water at $16\frac{2}{3}$° C. weighs in pounds = 62.321.

A cubic foot of air at 0° C. weighs in pounds = 0.080728.
1 litre of Hydrogen at 0° C., 760 mm., weighs 0.08969 g
1 Paris ft. = 0.32484 metres.
1 " line = 2.2588 mm.
1 Eng. ft. = 0.30479 m.
1 Gr. mile = 7.4204 kilom.
1 Eng. " = 1.60929 kilom.
1 Rhen. ft. = 0.31385 m.
1 metre = 3.2809 Eng. ft.
1 kilom. = 0.62138 Eng. mile
1 litre = 0.22017 gal.
1 " = 1.76133 pints.
1 kilogr. = 2.20462 lbs. avoir.
1 gramme = 15.43235 grains.
1 metre = 39.37 in.
1 U.S. gal. = 231 cu. in.

17. WEIGHTS AND MEASURES.

Measures of Length, English.

1 mi. = 8 fur. = 320 rods = 1760 yards = 5280 ft. = 63360 in.

Measures of Length, French.

1 kilo. = 1000 m. = 10000 dcm. = 100000 cen. = 1000000 mm.

Measures of Surface, English.

1 acre = 4840 sq. yd. = 43560 sq. ft.

Measures of Surface, French.

1 sq. H km. = 10 sq. D km. = 100 sq. m. = 1000 sq. dcm. = 10000 sq. cm. = 100000 sq. mm.

1 are = 100 sq. metres.

Measures of Volume, English.

1 cu. yd. = 27 cu. ft. = 46656 cu. in.

Measures of Volume, French.

1 cu. metre = 1000 cu. dcm. = 1000 litres = 1000000 ccm.

English Weights.

1 lb. avoir. = 16 oz. = 256 dr. = 7000 gr.

1 oz. = 437.5 gr.

French Weights.

1 kilo. g. = 1000 g. = 10000 dcg. = 100000 cg. = 1000000 mg.

MISCELLANEOUS.

Lineal feet × .00019 = miles.
Square inches × .007 = sq. ft.
Cu. inches × .00058 = cu. ft.
Cu. ft. × 7.48 = U. S. gallons.
Cu. in. × .004329 = U. S. gallons.
U. S. gals. × .13367 = cu. ft.
Cu. ft. of water × 62.5 = lbs. avoir.
Cu. in. of water × .03617 = lbs. avoir.
Metres × 3.2809 = ft.
Ft. × 0 3048 = metres.
Sq. in. × 6.451 = scm.
Scm. × 0.155 = sq. in.
Cu. in. × 16.386 = ccm.
Ccm. × .06103 = cu. in.
Litres × 61.027 = cu. in.
Oz. avoir. × 28.35 = grammes.
Lb. × 453.593 = grammes.
Gr. × 15.432 = grains.
Kilog. × 2.2046 = lbs. avoir.

18. TENACITY.

Copper, drawn	40.3	Silver, drawn	29.00
Copper, annealed	30.54	Silver, annealed	16.02
Iron, drawn	61.10	Steel, drawn	70.00
Iron, annealed	46.88	Steel, annealed	40.00
Lead, drawn	2.07	Steel cast, drawn	80.00
Lead, annealed	1.80	Steel cast, annealed	65.75
Platinum, drawn	34.10	Tin, drawn	2.45
Platinum, annealed	23.5	Tin, annealed	1.70

The above table gives the weight in kilogrammes required to break a wire of the substance 1mm. in diameter.

19. MENSURATION RULES.

Area of triangle = base × ½ altitude.
" parallelogram = base × altitude.
" trapezoid = altitude × ½ sum of parallel sides.
Circum. of circle = diameter × 3.1416.
Diameter of circle = circum. × .3183, or circle divided by 3.1416.
Area of circle = diameter squared × .7854, or radius squared × 3.1416.

Area of ellipse = product of diameters × .7854.
Area of reg. polygon = sum of sides × ½ apothem.
Lat. surface of cylinder = cir. base × alt.
Contents of cylinder = area base × alt.
Surface of sphere = diam. × circum.
Contents of sphere = diameter cubed × .5236.
Surface of pyramid } = cir. base × ½ slant height.
" " cone }
Contents of cone = area base × ⅓ alt.
Surface of frustum of pyramid or cone =
sum of cir. of bases × ½ slant height.
Contents of frustum of pyramid or cone =
⅓ alt. × sum of areas of bases and sq. rt. of product of these areas.

20. VELOCITY OF SOUND AT 32 DEGREES F.

	Feet per second.		Feet per second.
Air	1,093	Hydrogen	4,163
Ash	15,314	Iron	17,822
Brass	10,885	Lead	4,030
Caoutchouc	197	Maple	13,472
Carbon monoxide	1,106	Oak	12,622
Carbon dioxide	856	Oxygen	1,040
Cedar	16,503	Pine	10,900
Chlorine	677	Silver	8,553
Copper	11,666	Steel	17,182
Elm	13,516	Tallow	1,170
Ether	3,801	Turpentine at 24 deg.	3,976
Fir	15,218	Walnut	15,095
Glass	16,488	Water at 8.1 degrees.	4,708
Gold	5,717	Wax	2,811

21. MELTING POINTS.

	Degrees C.		Degrees C.
Antimony	425	Phosphorus	44.2
Beeswax	62	Platinum	1775 to 2000
Bismuth	270	Potassium	62.5
Brass	1020	Rose's metal	94
Bromine	—24.5	Silver	1000
Butter	33.0	Sulphur	115
Copper	1054.0 to 1200	Sodium	97.6
German silver	1093	Stearic acid	69.9
Gold	1250.0	Stearine	60
Ice	0.0	Spermaceti	49

Iridium	1950.0	Tallow (fresh)	43
Iron	1500.0 to 1600	Tin	235
Lard	33.2	Turpentine	−27
Lead	334	Wax, white	65
Margaric acid	59.9	Wood's metal	68
Mercury	−38.8	Zinc	433
Paraffine	38—52		

22. DENSITIES OF VARIOUS SUBSTANCES.

Acetic acid	1.060	Ice	0.917
Agate	2.615	Iceland spar	2.723
Alcohol, absolute	0.806	Iron, bar	7.788
Alcohol, common	0.833	Iron, cast	7.230
Alum	1.724	Iron, wrought	7.780
Aluminium	2.670	India-rubber	0.930
Amber	1.078	Iodine	4.950
Antimony, cast	6.720	Iron pyrites	5.000
Apple-tree wood	0.790	Ivory	1.820
Arsenic	8.310	Lard	0.947
Ash, dry	0.690	Lead, cast	11.360
Ash, green	0.760	Lead, sheet	11.400
Asphalt	2.500	Lignum vitae	1.333
Basalt	2.950	Lime, quick	0.843
Beech, dry	0.690 to 0.800	Limestone	3.180
Beeswax	0.964	Logwood	0.913
Bell-metal	8.050	Magnesium	1.750
Benzine	0.72 to 0.740	Mahogany	0.56 to 0.852
Benzole	0.899	Maple	0.755
Birch	0.690	Marble	2.720
Bismuth, cast	9.822	Mercury	13.596
Blood	1.060	Milk	1.032
Boxwood	1.280	Molasses	1.426
Brass, cast	8.400	Mortar, average	1.700
Brass, sheet	8.440	Naphtha	0.848
Brick	1.6 to 2.000	Nitric acid	1.38 to 1.559
Bromine	3.187	Oak, American red	0.850
Butter	0.942	Oak, American white	0.779
Calcium chloride	2.230	Oak, live, seasoned	1.068
Camphor	0.988	Oak, live, green	1.260
Carbon disulphide	1.293	Oil, castor	0.970
Carbon dioxide, liquid	0.947	Oil, linseed	0.940
Cedar, American	0.554	Oil, olive	0.915
Chalk	1.8 to 2.800	Oil, turpentine	0.870
Cherry-tree	0.710	Oil, whale	0.923
Chestnut	0.606	Paraffine	0.824 to 0.940
Chloroform	1.525	Petroleum	0.836

Clay	1.920
Coal, anthracite	1.26 to 1.800
Coal, bitum.	1.270 to 1.423
Cobalt	8.800
Concrete, ordinary	1.900
Concrete, in cement	2.200
Cork	0.240
Copper, cast	8.830
Copper, sheet	8.878
Deal, Norway	0.689
Diamond	3.530
Earth	1.520 to 2.000
Ebony	1.187
Elder	0.690
Elm	0.579
Elm, Canadian	0.725
Emery	3.900
Ether	0.736
Emerald	2.770
Feldspar	2.600
Fir, spruce	0.512
Fluor-spar	3.200
Galena	7.580
German-silver	8.432
Glass, flint	3.000 to 3.600
Glass, crown	2.520
Glass, plate	2.760
Glycerine	1.260
Gold	19.360
Gypsum, crys	2.310
Granite	2.650
Graphite	2.500
Gun-metal	8.561
Gutta-percha	0.966
Heavy spar	4.430
Honey	1.450
Human body	0.890
Hydrochl. acid, aq. sol	1.222
Phosphorus	1.830
Pear-tree	0.660
Pine, red, dry	0.590
Pine, white, dry	0.554
Pine, yellow, dry	0.461
Pine, pitch	0.660
Pitch	1.150
Platinum wire	21.531
Poplar, common	0.389
Porcelain, china	2.380
Potassium	0.865
Quartz	2.650
Rock-salt	2.257
Saltpeter	2.100
Sand, quartz	2.750
Sand, river	1.880
Sand, fine	1.520
Sand, coarse	1.510
Silver, cast	10.424 to 10.511
Slate	2.880
Sodium	0.970
Steel, unhammered	7.816
Sugar, cane	1.593
Sulphur, native	2.033
Sulphuric acid	1.840
Tallow	0.940
Tar	1.015
Tin, cast	7.290
Tourmaline, green	3.150
Vinegar	1.026
Water, at 100 degr. C.	0.958
Walnut	0.680
Water, sea	1.027
Wax, white	0.970
White metal, Babbitt	7.310
Willow	0.585
Zinc, cast	7.000

23. ACCELERATION DUE TO GRAVITY.

Berlin,	lat. 52° 30′	981.25 cm.
Greenwich,	" 51° 29′	981.17 "
Paris,	" 48° 50′	980.94 "
New York,	" 40° 43′	980.19 "
Washington,	" 38° 54′	980.06 "

Lat of 45°	980.61 cm
Equator, ...	978.10 "
Pole, ...	983.11 "

24. COEFFIENTS OF EXPANSION FOR 1 DEGREE BETWEEN ZERO AND 100 DEGREES C.

Linear.

Aluminium	0.00002221	Lead	0.00002799
Antimony	0.00000980	Marble	0.00000786
Bismuth	0.00001330	Paraffine	0.00027854
Brass	0.00001875	Pine	0.00000496
Bronze	0.00001844	Platinum	0.00000886
Copper	0.00001866	Sandstone, red...	0.00001174
Ebonite	0.00008420	Silver	0.00001943
Glass	0.00000861	Sulphur	0.00006413
Gold	0.00001466	Steel, tempered..	0.00001322
Graphite	0.00000786	Steel, unt'mp'r'd.	0.00001095
Iron, cast.......	0.00001125	Tin	0.00002730
Iron, wrought...	0.00001220	Zinc	0.00002976

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Did the other side escape your notice?